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EDMUND HELLER: 1875–1939

BY HILDA W. GRINNELL

There are in the museums of the United States so many specimens, gathered from four continents, which bear on the collector's label the signature "E. Heller" that it seems fitting to record something of the collector's life and travels. For certain facts the writer is indebted to Heller's sister, Mrs. George E. Tucker.

Born on May 21, 1875, at Freeport, Illinois, Edmund Heller was the son of Edward and Mary Ann [Schottle] Heller. When the boy was thirteen, the family moved to Riverside, California, a place which throughout his life he loved to call "home," and where he is laid to rest in the family plot in Olivewood Cemetery.

Country roads led far and wide from the little town and over them across the mesas to canyons and hilltops the boy rode on his pony. Often his companion was Harvey M. Hall, also eminent in later years, but as a botanist. The boys were devoted readers of the "Oologist" and their excursions had as an objective the collecting of birds and their eggs. E. B. Babcock (1934, p. 355), writing the biography of Hall, says that during their high school days the boys were stimulated and encouraged by an understanding teacher, E. A. Zumbro.

In the summers of 1896 and 1897 Heller collected in the Mohave and Colorado deserts, turning his attention more and more to reptiles and mammals. Later he became known especially as a collector of mammals, although he often put up birds as well.

Graduating from the Riverside High School, Heller entered Stanford University in the fall of 1896. From December 1898 through June 1899, Heller, in company with a fellow student, Robert E. Snodgrass, explored and collected in the Galapagos Islands. The expedition was made under the direction of the Zoology Department of Stanford University and was financed by Timothy Hopkins. The explorers sailed from San Francisco on the sealing schooner Julia E. Whalen, which visited each island in the group, as well as Clipperton and Cocos islands. Their itinerary is given in Heller's paper on the reptiles of the Archipelago (1903, pp. 39–42). Mammals, with the exception of the Cetacea, were reported upon by Heller (1904), but the paper on the birds (1904) was written with Snodgrass as senior author, as was the paper upon the shore fishes (1905). So industriously did the youthful collectors take in birds, mammals, reptiles, fishes, insects, mollusks, arachnids, crustacea, echinoderms and plants that their names have been

perpetuated by specialists describing endemic forms, such as *Dromicus occidentalis helleri* Van Denburgh, *Uca helleri* Rathbun, *Lipeurus helleri* Kellogg, *Telanthura helleri* Robinson, *Scalesia Helleri* Robinson, and *Opuntia Helleri* K. Schumann *in* Robinson.

The summer of 1900 was spent in the employ of the United States Biological Survey, as assistant to Wilfred H. Osgood in his investigations among the Queen Charlotte Islands, along the coast of southern Alaska, and in the Cook Inlet region. In commemoration of Heller's efficient services Osgood (1901, p. 181) bestowed the name *helleri* on the winter wren of Kodiak Island.

In 1901 Heller received his A.B. from Stanford University and shortly thereafter began the work which was to occupy him for the next six years as western field collector for the Field Columbian Museum. Oregon, California, Baja California, and Mexico were visited. Letters to old friends showed that the work was much to his liking. The vicissitudes of climate never evoked complaint. From Oregon he wrote in October, "I won't strike for a warmer climate as long as the collecting is good. I find that rainy weather aids me considerably, that is, my trapping success rises with the water." Neither did the snows of the San Pedro Mártir or the hot sands of the Colorado Desert evoke complaint.

The only indication of a ruffled spirit appears in a letter written from Juchitan, Oaxaca, Mexico, April 23, 1904: "Elliot has just published the results of my wanderings in Southern California, but as usual has succeeded in incorporating many awkward blunders and statements, especially in field notes. If you find the floral conditions existing about the summits of the Sierras transferred to Death Valley don't be surprised."

Elliot was, however, very appreciative of Heller's ability as a collector, as well he might be, for Heller's mammals afforded him the material for the naming of many forms. No type specimens are designated in his descriptions but the accompanying text refers repeatedly to Heller's notes. To at least three mammals, *Dipodomys deserti helleri*, *Thomomys helleri*, and *Perognathus helleri*, the collector's name was given "in recognition," Elliot (1903, p. 166) states, "of his most capable services to this Institution, for which he is an official collector."

In midsummer of 1905 Heller was recalled from Guatamala to the Field Museum to become a member of the African expedition being organized under the direction of Chief Taxidermist Carl E. Akeley. This opportunity to work under a man from whom he could learn much pleased Heller greatly. The fourteen months spent with Akeley in central East Africa schooled Heller admirably for later expeditions.

On his return journey Heller visited Naples, Rome, Venice, Paris and London. Later he studied collections in Berlin.

Early in 1908 Heller joined the staff of the Museum of Vertebrate Zoology founded by Miss Annie M. Alexander at the University of California. His first assignment was to prepare an account of the mammals of the 1907 Alexander expedition to southeastern Alaska (1909). Some weeks were spent in Washington comparing the specimens secured by the expedition with those in the collections of the Biological Survey.

Heller's sense of fairness is exemplified in a letter written at that time: "Under the head of the various localities I have given the field notes of Stephens and Dixon, these of course arranged under their species. Have also given a list of the specimens under each species with their sex, date, locality and collector so as to give credit to the various collectors ..... This method is a space killer but it's about the only way to give the collectors a square deal."

Heller accompanied the 1908 Alexander Expedition to the Prince William Sound region of Alaska and was author of the report upon mammals of the area (1910).

With the planning of the Smithsonian-Roosevelt East African Expedition of 1909–1910 there came a request from President Theodore Roosevelt to President Wheeler of the University of California for the release of Edmund Heller from his duties in the Museum of Vertebrate Zoology in order that he might accompany the expedition, as he had been recommended by Carl Akeley for the position of naturalist in charge of the preservation of big game animals.

The choice was a happy one, for the two men proved to be especially congenial. Heller wrote from Washington (February 1, 1909): "A few days ago I met the President at lunch in the Whitehouse [sic]. He was extremely pleasant and jolly and talked enthusiastically of the coming trip. He already possesses a remarkable knowledge of the game animals of East Africa, a knowledge equal to that of a naturalist who has visited the country and supplemented his experiences by a study of the literature." Heller's first impression was a lasting one.

Roosevelt, himself, speaks in his writings of Heller's never failing cheerfulness under trying conditions and of his coolness in the face of danger. Of the part Heller took in the expedition's work Roosevelt wrote (1910, p. 93): "He it was who handled all the skins, who, in other words, was making the expedition of permanent value as far as big game was concerned; no work at any hour of the day or night ever came amiss to him." The party sailed from New York on March 23, 1909, and disbanded at Khartoum on March 14, 1910. The narrative of the itinerary and adventures has been fully chronicled by the leader himself (Roosevelt, 1910).

Together Roosevelt, senior author, and Heller prepared "Life Histories of African Game Animals" (1914). The two volumes were reviewed by C. Hart Merriam (1916, pp. 148–153). Of the junior author's contribution he says: "Heller's descriptions of the animals are clearly stated, easily understood, and may be regarded as models of their kind." The scientific reports on the mammals were made by Heller alone. They are listed in the appended bibliography. Of the 150 new forms which he described, 27 have been relegated to synonymy by later writers with access to more abundant material for comparison.

The writing was done in Washington, but Heller's residence there was interrupted by a third East African trip, when the Smithsonian Institution accepted a suggestion from Paul J. Rainey that it send a mammal collector with his expedition to East Africa for six months in the field, all material collected to become the property of the Institution. The expenses of the expedition were

paid by Mr. Rainey alone. The route of travel lay entirely north of the country traversed by the Roosevelt expedition, through the northern part of British East Africa and the southern part of Abyssinia.

From Naples, Italy, on March 2, 1911, Heller wrote to his old friend, Joseph Grinnell. "Mr. Rainey intends to spend six months in the game country bordering Abyssinia. He is outfitted chiefly for excitement. We have with us a string of cow ponies for roping game, a pack of bear dogs for running the game down and a moving picture expert for getting a record of the battles which are sure to take place . . . ." The report of the Secretary of the Smithsonian Institution for 1912 states that the Rainey Expedition returned with 4,700 mammal skins, in addition to many specimens of birds, reptiles, and other animals.

Ned Hollister (1918b, p. 25) wrote of Heller's African work: "Great credit is especially due to Mr. Heller for his success in the field on both of the major expeditions, and his interest in the preliminary arrangement and classification of the collections assembled by himself and his colleagues. His notes on specimens in European museums and the specimens compared by him with the types in those institutions, as well as his exceedingly interesting and valuable journals of the field work, have been of great help in the present work."

In the summer of 1914 Heller accompanied Lincoln Ellsworth to the Stikine River and Cassiar Mountains of British Columbia to collect specimens of big game for the Biological Survey.

Heller twice visited Peru. First in 1915, as collector with the Yale University-National Geographic Society Expedition to the Urubama Valley of Peru, above which lie the Inca ruins of Macchu Picchu. Here he was in the field from April to November and made collections from the upper limit of life above La Raya Pass (altitude 14,200 feet) to the dense forests of the tropical zone of the Rio Comberciato (altitude 1,800 feet). Heller's collection of 884 mammals was reported upon by Oldfield Thomas (1917, 1920); the 757 birds by F. M. Chapman (1921); and the 150 lower vertebrates by Thomas Barbour and G. K. Noble (1921). Chapman visited the region himself before concluding his report upon the birds, but for descriptions of climate, terrain, and vegetation he relies largely on Heller's field notes.

In 1916 Heller was employed as collector of small mammals on the Asiatic Expedition of the American Museum of Natural History. Joining the leader, Roy C. Andrews, in the coast province of Fokien, China, work was there carried on through July and August. Then proceeding via Hong Kong through French Indo-China to Yunnan a caravan was outfitted for travel westward to Tali-fu and northward through Li-Chiang to the Tibetan border and the headwaters of the Yangtze River.

While in the vicinity of Li-Chiang, the expedition worked for seven weeks on the slopes of a mountain 18,000 feet high, collecting in that time 1,100 mammals. Early in January, 1917, the expedition turned southward toward the Indian border and low tropical country in search of leopards, tigers, and small mammals. During their year in the field the members of the party travelled 2000 miles on horseback, camped at 108 localities, and lived at altitudes varying from 1,500 to 15,000 feet.

In the summer of 1918 Heller accepted an invitation from Paul J. Rainey to accompany him to Siberia, as Rainey had become official photographer to the Czech army in Siberia, where 50,000 Czech soldiers were holding the railroad for the allies. With Rainey he took an 8,000 mile railway journey across Siberia to the Ural Mountains and European Russia and back to their starting point, as the war ended.

In the summer of 1919 he paid his fourth visit to Africa; with an expedition officially titled "Smithsonian African Expedition under the direction of Edmund Heller in conjunction with the Universal Film Manufacturing Co." Members arrived in Cape Town, South Africa, on August 13, 1919. Here an outfit was assembled. The expedition visited the Victoria Falls of the Zambezi River, western Rhodesia, the source of the Congo River in the Belgian Congo, and then turned eastward to Lake Tanganyika. From headquarters on the eastern shore of the lake, excursions were made into the former German East Africa and the Uganda Protectorate.

When the Roosevelt Wild Life Forest Experiment Station was established in 1919 as a memorial to Theodore Roosevelt, it received the hearty support of Edmund Heller, who was one of the dedication speakers (1921).

In the fall of 1921 Heller donated fifteen weeks of time, under the auspices of the Station, to the making of a survey of the big game animals of Yellowstone Park. Here he hunted with camera instead of gun. He writes (1925, p. 409): "... I have never passed time more pleasurably and profitably than in this present natural history investigation. I learned more about the habits of the animal species observed during these few months than in all my previous hunting experience." On another page of the same report (1925, p. 448) he expresses the conviction: "*A National Park should never be made a zoological garden* [italics his]. It should harbor only its own natural fauna in normal numbers and should be a sanctuary where the animals are to be sought rather than a place where they are on exhibition."

Upon his return from a trip, Heller often talked informally before a scientific group concerning his travels. Twice during his adventurous career he turned professional lecturer, once for a brief period in the fall of 1921, and again in 1927, following his resignation from the staff of the Field Museum.

In the fall of 1921, Wilfred H. Osgood was appointed Curator of Zoology at the Field Museum, succeeding the late Charles B. Cory. Shortly thereafter Heller was added to the staff as Assistant Curator of Mammals, a position which he held until his resignation in 1927. Early in 1922 Heller was assigned to further field work in Peru. Sailing for South America on April 12th, he worked at first about the headwaters of the three most important tributaries of the Amazon, the Maranon, the Huallaga and the Ucayali, later in the upper valley of the Amazon itself. The work was continued into 1923, terminating in a return to the Field Museum for the making of preparations for a new African adventure, the "Captain Marshall Field Central African Expedition." On this, his last expedition to Africa, Heller was engaged from the autumn of 1923 until October of 1926.

During 1924 work was carried on chiefly in the eastern part of the Belgian Congo, in or near the great rain forest of central Africa, haunt of the great apes,

Early months of 1925 were spent at high altitudes on Mount Ruwenzori, on the eastern edge of the Belgian Congo. From Ruwenzori Heller went westward into the Ituri forest, home of the Pygmies and the elusive Okapi. Later, gorillas were sought and found in northwestern Uganda.

Heller's work in Africa is commemorated in the names of three birds described by Mearns, *Francolinus hildebranti helleri* (1913a, p. 381), *Planesticus helleri* (1913b, p. 1), and *Pogonocichla cucullata helleri* (1913c, p. 1), and in the naming of two mammals, *Otomys jacksoni helleri* Frick (1914, p. 10), and *Aethomys kaiseri helleri* Hollister (1918a, p. 97).

The last eleven years of Heller's life were devoted to the care in captivity of many of the large game animals he had known in the wild. The contrast between their lives in the open and as prisoners always distressed him. It was his conviction that since the public demands zoological parks no pains should be spared to make the inmates as comfortable as possible. "Architects usually detest the sight of outside cages draped around the stately walls of their buildings," he wrote. "They feel that it kills their architectual effect." But he battled continually for the outside cages which would give his charges sunlight, for the wide moats which would protect them from the public, and the dark lairs where they might rest in peace and quiet.

Heller's first charge was the directorship of the Milwaukee Zoological Garden. Here he served from 1928 to 1935. One of his duties was the editing of the Bulletin of the Washington Zoological Park Society, which sponsored the Zoo and supplied the animals. Many of his excellent contributions are unsigned. "Polar bears reared in Milwaukee" (signed as republished in Parks and Recreation, 1930) and the "American Prong-Horned Antelope" (1930) are entertainingly written and full of good natural history. His improving of the living quarters and the diets of his charges resulted in the successful rearing of animals rarely found adapted to captivity.

In 1935 Heller resigned his position in Milwaukee in order to become director of the Fleishhacker Zoo in San Francisco, where his aid was needed in the planning of the new Zoo, as well as in maintaining the old one.

Here in the Bay region, with congenial work, and near old friends of his college days, he would have been happy except for the increasing inroads made upon his health by asthma, an old enemy. Severe attacks so injured his heart that death resulted on July 18, 1939, after three weeks confinement to his cottage on the grounds of the Zoo. During his last illness the same determination which had carried him through jungles and deserts kept him busy on the book which he had planned on the breeding habits of the Felidae.

Heller was a member of the Cooper Ornithological Club from 1894 until his death, and a charter member of the American Society of Mammalogists, founded in 1919. In 1930 he was chairman of the Committee on Statistics and Publications of the American Association of Zoological Parks and Aquariums. In 1937 he became chairman of the American Association of Zoological Parks.

Roger Conant (1939, p. 639) wrote of Heller: "Everywhere he went he made a name for himself and endeared himself to all those with whom he was associated.

There was but one Edmund Heller and his passing leaves a void that no one else can fill."

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A SURVEY OF THE BEAVER POPULATION OF ROCKY MOUNTAIN NATIONAL PARK, COLORADO

By Fred M. Packard

Between January 3, 1939, and December 5, 1940, the writer was engaged in investigations of wildlife problems in Rocky Mountain National Park, Colorado, for the National Park Service. One of these studies consisted of a general survey of the beaver population of the park, designed to provide data upon which to base administrative policies regarding the proper management of the lands occupied by beavers and the perpetuation of the beaver population at optimum conditions.

In order to coordinate this survey with the state-wide study of beavers being made by the Colorado Pittman-Robertson division, the methods devised by the state investigators for their own work were employed in the national park. Each stream and its tributaries were paced to determine the location of beaver colonies; in a few cases measuring was done by car on roads adjacent to streams, while stretches of certain streams quite unsuited to beavers were estimated from maps or from the length of trails nearby. Ecological data were recorded on forms supplied by the state organization, and where time permitted, the essential information was transferred to straight-line diagramatic maps of each stream and its beaver colonies. These forms and maps may be referred to at the offices of the national park in Estes Park.

Dr. E. A. Warren surveyed the beaver colonies on Cow Creek and other streams in the Estes Park region east of Long's Peak, publishing his results in a detailed paper (Notes on the Beaver in Estes Park, Colorado, Roosevelt Wild Life Annals, vol. 1, no. 2, pp. 193–234, 1926). In making his survey he assumed that eight beavers inhabited each lodge then is use. The state men, however, consider six beavers to a lodge more nearly accurate, and figure that two beavers occupy each bank burrow. Other studies in Missouri and elsewhere are based upon an estimate of seven beavers to a lodge. These opinions can be argued, but to correlate the present work with the state survey, the state's method was used. The crowding of beavers on some streams in the park indicated that certain exceptionally large lodges were inhabited by two or three families, and a correspondingly higher estimate was made in such cases. The advice of Park Naturalist H. Raymond Gregg and Rangers Jack Moomaw, Harold Ratcliff and Fred McLaren, of the park staff, was especially helpful on this point.

The subspecific identity of the beaver inhabiting the park is uncertain. Formerly it was assumed that *Castor c. frondator* of the lower Colorado River valley lived on the west side of the continental divide, and that *Castor c. missouriensis* inhabited the eastern slope. In 1939, E. A. Warren and E. Raymond Hall, described a new subspecies, *Castor c. concisor*, from Colorado. One specimen from the park was referred to *concisor* by scientists of the United States National Museum, and a series of nine skins in the American Museum of Natural History from the park are doubtfully referred to *concisor*. It would be of value to have

a series of park beavers collected and the skins and skulls properly classified. Until better evidence is available, the park beaver may be assumed to be *Castor c. concisor*.

Rocky Mountain National Park includes 502 square miles of high mountain terrain and the headwaters of four (possibly five) drainage systems, each with tributary streams and associated lakes. These systems rise high on the mountain slopes, many of them originating in lakes or springs above timberline, which is at 11,000 feet, or slightly below that elevation. Due to the gradient of the slopes, most of the higher parts of the streams are unsuited for beaver, or poorly suited to their occupancy, being narrow, rocky and turbulent, and lacking suitable vegetation. As these streams descend, the slope decreases, and they enter long glaciated valleys, locally known as "parks", where they broaden and the flow slackens, while willow and aspen become abundant, providing ideal conditions for beaver colonies.

The following discussion of the beaver colonies on these drainages includes descriptions of the ecological conditions peculiar to each tributary. The drainages are discussed as units, the tributaries and lakes being arranged in their geographical position counterclockwise from Estes Park village. Environmental conditions change markedly a short distance below the national park on all of these streams, the eastern drainages entering canyons through the foothills to the plains 30 miles distant, while the Colorado River on the west flows into dry Upper Sonoran basins below Grand Lake village. These changes in the environment are such as to preclude the establishment of important or permanent beaver colonies in those regions.

THE THOMPSON RIVER DRAINAGE

North Fork of the Thompson River.—The north fork rises in several alpine lakes at the foot of the Rowe Glacier north of Mts. Dunraven and Dickinson, and flows eastward out of the park. The only beaver colony on this stream within the park is about a mile east of Lost Lake, where a single lodge stands in an arctic willow swamp slightly below timberline. The course of the stream descends gradually to 9300 feet at the park boundary and offers considerable habitat for future colonization by beavers. A number of deer and elk inhabit this region and compete with slight effect for the willows and grasses.

West Creek.—This stream rises in a broad alpine valley above timberline on the east slope of Mummy Mountain. In spring it is swift, and much of it physically unsuited to beaver. As far as could be determined, no beavers were living there in 1939 or 1940; scattered patches of aspen had been cut at least ten years previously, but none in recent years. The evident factor deterring beavers from settling on this stream is the lack of available food.

Cow Creek.—Cow Creek rises as two branches, one draining the north slope of Lumpy Ridge and Wonder Basin, the other the unnamed mountain to the north. The central portion of this stream has served as habitat for more beavers in the past than at present. Practically all of the aspen groves adjacent to it have long been cut by beavers, probably 20 years ago or more, and they have not recovered. Elk and domestic stock occupying the meadow have cropped all the young shoots so constantly that reproduction from the stumps has ceased. Willow forms the principal food species for beavers in the area and much of that is too sparse to support a colony, or has been killed by elk and stock browsing.

Most of this stream is entirely unsuited to beaver, except at the upper sections, where the aspen groves afford potential food supplies. The chances of permanent colonies being maintained on the lower reaches are slight.

TABLE 1.—*Beaver Population of Rocky Mountain National Park*

STREAM	LODGES	BURROWS	PRESENT POPULATION	CARRYING CAPACITY
Thompson River Drainage				
North Fork	1	0	6	More
West Creek			0	Slightly more
Cow Creek	4	?	24	Slightly more
Black Canyon Creek	0	0	0	Few or none
Fall River	13	9	96	Slightly more
Bighorn Creek	—	—	Not surveyed adequately	Few or none
Roaring River	1	1	7	As at present
Hidden Valley Creek	10	?	70	Fewer
Beaver Creek	6	?	36	More
Thompson River	52	13	315	Many fewer
Windy Gulch Brook	12	?	65	As at present
Forest Canyon Creek	—	—	Not surveyed	Probably few or none
Hayden Creek	—	—	Not surveyed	Probably few or none
Spruce Creek	—	—	Not surveyed	Probably few or none
Fern Creek	—	—	Not surveyed	Probably few or none
Cub Creek	7	5	60	As at present
Mill Creek	22	5	144	Fewer
Glacier Creek	18	4	150	As at present, or more
Wind River	3	?	18	Slightly more
Aspen Brook	—	—	Not surveyed	Not determined
Lily Lake	0	1	2	More
Fish Creek	—	—	0	Few or none
Cache la Poudre Drainage				
Cache la Poudre River (to north slope, Specimen Nt.)	20	13	150	Slightly more
South Fork			Not surveyed	Probably few
Cascade Creek			Not surveyed	Not determined
Hague Creek			Not surveyed	Not determined
Chapin Creek			Not surveyed	Not determined
Specimen Creek			Not surveyed	Not determined
Long Draw	1	?	6	Not determined
Colorado River Drainage				
Colorado River and tributaries within the national park	?	?	630	As at present
Tonahutu Creek	—	—	Not surveyed	Not determined
North Inlet	—	—	Not surveyed	Not determined
East Inlet	1	0	6	More
Grand Lake	1	0	6	More
The Outlet			0	Very few or none
North St. Vrain Drainage				
Oriole Creek			Not surveyed	Not determined
Cony Creek			Not determined	Very few
Pipit Lake, Junco Lake, Bluebird Lake, Ouzel Creek and Ouzel Lake			Not determined	Very few
Eagle and Pitt Lakes to N. St. Vrain Creek			0	None

TABLE 1.—*Continued*

STREAM	LODGES	BURROWS	PRESENT POPULATION	CARRYING CAPACITY
Lion Lake, Thunder Lake to N. St. Vrain Creek			0	Probably none
Sandbeach Lake and outlet			0	Probably none
Hunter's Creek		1	2	Slightly more
Camper's Creek			0	None
Horse Creek			0	None
Cabin Creek	3	?	30	More
Inn Brook	3	?	18	More
Cow Creek	3	?	18	More

Totals:	North St. Vrain Drainage	68
	Colorado River Drainage	642
	Cache la Poudre Drainage	156
	Thompson River Drainage	999
	Grand Total	1865

Black Canyon Creek.—Black Canyon Creek rises between Lumpy Ridge and MacGregor Mountain, flowing southward into Estes Park. The upper part of the stream is steep and full of boulders. Below the park boundary it flows east through sloping pastures used by livestock. Some aspen is available, but livestock competition will probably prevent colonies from becoming established.

Fall River.—Fall River rises above timberline near Fall River Pass, and descends with considerable swiftness into Horseshoe Park. No beaver colonies were found above 10,000 feet in this valley, and only one colony was found on the river itself above Horseshoe Park. However, several colonies have been established at places where small tributaries from the steep slopes of the canyon join the river, where aspen is available. These were surveyed inadequately, but at least four occupied lodges were found.

Horseshoe Park, a narrow meadow about a mile long at 8200 feet, supports several colonies of beavers. There is an abundance of willow, and several stands of aspen are growing along the south side of the park and at the head of the meadow. The beavers have established a considerable series of dams and ponds near the artificial fish pond south of the stream, taking advantage of the outlet for their purpose. Another colony is located at the junction of Hidden Valley Creek with Fall River in this meadow. There appears to be an adequate supply of aspen and willow to support the present population, but there is not much available for overflow colonies. Elk are doing some damage to the willow and aspen in this area.

Roaring River.—Roaring River rises in Crystal and Lawn lakes, draining the southern slopes of the Mummy Range. Above 9500 feet it is too small to be a likely site for beaver colonies, although willow is available there. Below 9500 feet, on the hanging valley above Horseshoe Park, there are signs of former occupancy. In 1939 an abundance of fresh cutting was found there that probably represented the work of a single beaver. One active lodge and pond were found on a small tributary emptying into Roaring River. Most of the lower part of the stream is too swift and rocky for colonization.

Hidden Valley Creek.—This creek rises as the drainage of the north side of Trail Ridge at over 12,000 feet. It drops swiftly through the conifer belt into Hidden Valley at 10,000 feet, through which it flows more slowly. This valley is a sedge swamp, with some willow, but much of the willow has been cut by beavers and some has been killed by elk. Young aspens fill the western end of the valley and the adjacent hillside, covering the scar of the fire of 1914, but beavers have as yet made little use of these trees, which will eventually be a

valuable source of food and material to them. The eastern end of this upper valley is covered by a large pond, which was almost completely dry in 1939 but refilled in 1940. A small lodge has been built on the shore of this pond, but there is little food immediately available for the maintenance of this colony.

Dropping through a narrower valley, the stream enters a lower meadow where there are two large, old ponds. This colony is decadent; almost all of the willow and all of the aspen near the ponds have been cut. The beavers are obtaining aspen from more than a 150 feet up the hillside. There is probably barely enough food there to support the present population, and the young beavers have to move downstream. East of the road, another series of dams and two very old lodges form another colony. Here most of the available aspen has long been cut, and most of the willow is either flooded, dead, or partly killed by elk. There is no possibility of support for the annual increase.

Beaver Creek.—Beaver Creek rises as two branches at the foot of Trail Ridge at about 9000 feet. The southern branch is unsuited for beaver. The northern branch rises in a fine stand of aspen, which continues for a mile down its course, and in places provides suitable habitat for beaver. The two branches join near the foot of the broad valley, and the stream soon reaches Beaver Meadow. There irrigation ditches decrease the amount of water in the stream itself, but beavers could become established at many places in the upper meadow. Three colonies there at present appear to be doing well. Most of the upper meadow lacks aspen available to beavers, which must, therefore, subsist on grasses and willows that are heavily browsed by elk. A dying stand of aspen borders the stream in the eastern end of the meadow, which could provide food and material for a number of beaver. The only colony now in this grove is at the extreme eastern end, at the head of the lower canyon.

Beaver Creek offers considerable habitat for future colonization, and will probably be occupied by animals overflowing from more crowded streams. The band of over 200 elk that winters in Beaver Meadow, with many deer, have killed much of the aspen and willow there, and are probably having a detrimental effect upon the potential food supply of the beavers.

Thompson River.—Thompson River rises between Trail Ridge and the Front Range. The steep, conifer-clad upper reaches are unsuited to beavers, although reports were received of colonies in Odessa Lake and other lakes and tributaries that were not visited by the writer. A single bank burrow was found near Fern Lake Lodge. Other than this, no colonies were found much above the head of Moraine Park.

Where it enters Moraine Park, the stream is about 25 feet wide, but it forks eastward and is absorbed in a wide willow swamp. Several currents cross the marshes and timothy meadows that form Moraine Park proper. These currents join to reform the Thompson River at the foot of the grasslands. There is almost no aspen available to beavers in Moraine Park, except for a few small stands at the western end at the foot of the moraine. The beavers are living on the thick willow growth that borders their ponds and forms fringes along the currents. In many places the carrying capacity has been overreached, and the crowding is detrimental to the beavers as well as to private property. The only outlet for the yearly increment of beaver is the lower parts of the river below the park boundaries, and that region is unsuited to beaver. There is no indication that the supply of willow will soon be exhausted, but it is already insufficient to maintain the large numbers of beavers inhabiting the marsh, and it is suffering from competitive use by elk and deer, while livestock grazing reduces further the amount of grass available.

Between the park entrance and Estes Park a few small colonies are found in moist willow meadows where enough food is available. All of these are poor sites, however.

Windy Gulch Brook.—Rising in the bowl that forms the eastern summit of Trail Ridge, this stream drops swiftly into a flat hanging valley at 9400 feet that supports a thriving, long established beaver colony. Most of the available aspens have been cut, and long canals lead to more distant stands. There is still a good stand of aspen on the southern edge of the meadow, and much of the recent beaver activity has been concentrated near this area. The number of lodges indicates a crowded condition, and there is little room for the

annual increment, which must move downstream to the already overpopulated Thompson River.

Cub Creek.—This creek rises in Cub Lake and flows southward parallel to the upper Thompson River to Moraine Park, where it joins that river. When Cub Creek is full, as in 1939, it affords a number of good sites for colonies; its bed slopes gently and there is a moderate amount of standing aspen available to the beavers, and abundant willow. In dry seasons, as in 1940, lack of water may force some of its beaver population to evacuate, but such abandoned sites are probably reoccupied in later wet years.

There is one large active lodge on Cub Lake, and another that is probably occupied intermittently. Below the lake is a succession of ponds and colonies, including at least six inhabited lodges at the time of the survey. One of these lodges is enormous, about 65 feet long, and is normally inhabited by two or perhaps three families of beavers. In 1940 Park Naturalist Gregg reported that it had probably been deserted. In addition, there are a number of bank burrows. The total population of the stream appears to fluctuate with annual conditions, but probably is as large as the stream will support.

Mill Creek.—Mill Creek rises from a spring north of Bierstadt Moraine. Aspens are abundant there, and beavers have developed a series of ponds and canals, with one or two lodges and several bank burrows. The stream descends through a narrow, rocky canyon to a half-mile long meadow at 8200 feet. The northern part of the meadow is pasture; the center is a morass of alder and willow thickets bordering dozens of beaver ponds now in use. At the foot of the Bierstadt Moraine are several stands of aspen, utilized by the beavers. At one place the beavers are dragging logs from trees they have cut 400 feet up the hillside to their ponds below. The aspen is relatively healthy and little scarred by elk. East of the Bear Lake road is a single colony, while two others are located on adjacent tributaries. The lower part of the stream is unsuited to beaver.

Glacier Creek.—Beginning at Bear Lake, 9500 feet, Glacier Creek drops swiftly through Prospect Canyon to the Glacier Basin Campground. Most of the main stream is too swift and boulder-filled to maintain colonies, although a number of beavers have established themselves where short stretches of the stream flow over more level ground. Below the campground the creek plunges down a second canyon, joined by Mill Creek midway to its junction with the Thompson River, just outside the national park.

A number of small tributaries rise in lakes and canyons north of Longs Peak, joining the creek at various points along its course. This area was the scene of a large fire in 1900, and an abundant supply of aspen now covers the lower parts of the burned area. Many small colonies have been developed along these tributaries, some of them containing exceptionally fine examples of beaver workings. The number of beavers in this region will probably increase for several years.

Wind River.—There are about three lodges on Wind River, which drains the northern slopes of Battle Mountain, north of Longs Peak. The declivity becomes increasingly gentle, and aspen is fairly plentiful along the stream, which probably can support a few more beaver than it does at present.

Lily Lake and Fish Creek.—Formerly a number of beavers lived beside this lake, but they were trapped out regularly at the request of the owner. At the time of the survey, a single pair had reoccupied the lake.

Fish Creek rises in Lily Lake, and drops eastward through a tangle of aspen, alder, willow and other plants into a broad grass-covered valley that forms the southern section of Estes Park. A fringe of tall aspens borders the stream for a mile into the valley; eastward, this is replaced by a fringe of willows and alders. Lying entirely outside the national park, the stream joins the Thompson River 6½ miles below Lily Lake. Small, frequently dry, flowing through heavily grazed pastures, the stream is entirely unsuited to beavers, and is used by them only temporarily, if at all.

THE CACHE LA POUDRE DRAINAGE

Cache la Poudre River.—This river rises in Poudre Lakes, at Milner Pass on the continental divide. Poudre Lakes are shown as two large ponds on the topographic map of 1919,

but the single dam beavers have built at the outlet has raised the water level to form one lake. Lying about 200 feet below timberline between densely conifer-clad slopes, the only food available to the beavers there is a thick growth of arctic willows. One of the two lodges is very old, while the smaller was probably begun in 1939. There is enough grass and willow to support the present population, although there is considerable competition with muskrats for food. It has been suggested that this colony, at 10,107 feet, may be one of the highest in the United States.

The river drops rapidly eastward from the lake, receiving as it progresses drainage waters from Mt. Ida and Specimen Mountain. Beaver colonies have been established in considerable numbers along the stream. The lodges associated with these colonies are of normal size, but by necessity have been built entirely of willow, grass and volcanic mud. This does not cohere well, so that the lodges weather easily and are not very substantial. Whether this fact is a factor in the eventual abandonment of the colonies is not certain, but most of the colonies occupied at present are located immediately above older sites that have been drained by the beavers and abandoned. However, draining itself does not imply that the site is deserted. In some cases new lodges have been built beside partly-drained ponds, and the original lodge may even be occupied.

Inspection of the meadows beside the stream revealed that most, if not all, of the present grassland has at one time or another been the site of beaver colonies. Some of these grass-grown meadows can hardly be recognized as former beaver ponds now, but, from indications, beavers have probably been living here in numbers for hundreds of years. Although the parts of the stream now occupied probably could not support any more beavers than are there now, there is room available along the river for some of the annual increase. The lower part of the stream was not surveyed, but it doubtless contains a large number of beavers.

LONG DRAW

This long lake flows along the northwestern boundary of the national park for a mile or so, and continues northward beyond the park; it is probably a part of a separate drainage system, although its outlet may eventually join the Cache la Poudre River far outside the park. Although one small lodge was found near the southern end of the lake, it is generally unsuited to beavers.

THE COLORADO RIVER DRAINAGE

Colorado River.—The headwaters of the Colorado River include a small lake, named Poudre Lake (but not to be confused with Poudre Lakes at Milner Pass), from which the river flows southward between the Never Summers and Specimen Mountain and the other peaks that form that part of the continental divide that bisects the national park. The stream is fairly broad, and there is some willow in the upper reaches, but the grade is too steep for several miles down its course to provide conditions suitable for beaver. At Lulu Townsite, a long abandoned pioneer settlement, the valley begins to broaden and becomes more level southward. Lying between lodgepole covered hills, this valley is a flat, moist willow marsh, with luxuriant grasses, small areas of which are cultivated as hay meadows. Most of the valley is occupied by dude ranches, the national park boundary crossing it about half-way to Grand Lake village, the river forming the west boundary of the park south to Grand Lake.

There is a single colony of beavers at Poudre Lake, and between Lulu Townsite and the Holzwarth Ranch, several miles below where the national park boundary crosses the valley, colonies occur almost regularly. It was estimated that approximately 600 beavers live in this valley within the national park. A number of small tributaries drain the peaks on both sides of the valley, joining the river at various points on its course. These swift, narrow watercourses appeared to be generally unsuited to beavers, although it is possible than an occasional colony might be located in the higher Never Summers, while about 30 beavers occupy colonies on streams draining the western slope of the divide.

East Inlet.—The East Inlet to Grand Lake rises in a series of deep lakes at the western foot of Mount Alice, the principal of these being Lake Verna. Beavers have occupied these lakes in the past, but do not appear to be there at present. There is one colony about a mile east of Grand Lake on this stream.

Grand Lake.—No beavers inhabit the shores of Grand Lake itself, but there is one thriving colony near the road crossing at Grand Lake village on a small unnamed tributary.

The Outlet.—The Outlet drains Grand Lake, runs a brief distance outside the national park, but shortly forms its western boundary to the southwestern corner. This stream was surveyed as far south as Pole Creek. It is unsuited to beavers physically, and food and building material are scarce. One old dam was found, and possibly one or two bank burrows, but there is no cutting associated with them. Ranger McLaren reported that beavers are not infrequently seen on the Outlet, but the indications were that these were temporary residents or itinerants.

THE NORTH ST. VRAIN DRAINAGE

These streams and lakes (see Table 1) drain the southeastern corner of the park, and were surveyed by Ranger Charles Hardin. Except for Cabin, Inn, and Cow creeks, they are all unsuited for beavers, and none has been reported on them, although isolated colonies may be present. They are mostly small, turbulent, and surrounded closely by dense stands of conifers, with little food or building material, and few places for them to construct dams and lodges.

The following streams of this drainage system were the major subjects of Dr. Warren's investigation in 1926. Conditions have changed considerably since his report was written. The colonies are less extensive; many ponds have been drained or dried up, and the number of beavers has decreased. Some of the colonies he described could be identified from his report, but for the most part this was impossible. Part of the areas he describes as sites of beaver colonies appear to be changing to meadows with much less water in the streams and fewer ponds.

Cabin Creek.—Cabin Creek drains the eastern slopes of Mount Meeker, dropping swiftly from timberline to 9500 feet. The two forks flow thence through more nearly level valleys of lodgepole pine, willow, alder and aspen to their junction just east of the park boundary. The southern branch is reported to contain no beavers, but between 9000 feet and 9500 feet on the northern branch a series of ponds with lodges supports an estimated population of 25 animals. At Camp St. Malo, at the park boundary, beavers inhabit a willow swamp and the stream below to its junction with Cow Creek. These beavers are reported to flood private property and to cut desirable stands of aspen.

Inn brook.—Inn Brook rises slightly east of Long's Peak Inn, and flows southwestward between Long's Peak and Twin Sisters Peak. Although Dr. Warren discovered many beavers on this stream, only three active lodges were found there in 1940. Most of the old abandoned sites are turning to meadow, and there is evidently less water in this stream now than formerly.

Cow Creek.—Cow Creek rises on the northern slope of Twin Sisters Peak (this is a different stream from the Cow Creek of the Thompson River drainage system) and flows southward into the North St. Vrain. Most of the many beaver sites found there by Dr. Warren are turning to meadowland, and only one active colony of three lodges was located on the stream in 1940.

DISCUSSION

Technicians who are familiar with conditions in other national parks have told the writer that Rocky Mountain National Park probably supports more beavers than any other. This assumption is probably correct, since there is an abundance of food and building material on many of the important streams, and almost every stream that can support beavers is stocked to capacity or is overpopulated.

For the most part, the beaver population of the park is fairly stable, fluctuating with conditions that permit its increase or enforce its decrease in the various regions. On such streams as the Cache la Poudre River beaver colonies have waxed or waned healthily for centuries. On others, various factors have produced an undesirable concentration of beavers in certain localities.

When beavers settle on a stream or section of a stream that is physically unsuited to them, it is probable that their residence is temporary, and that eventually they will seek better sites. These animals appear to be wandering individuals, probably either very old members of an established colony farther upstream or young of the year crowded out of it.

Lack of aspen available for food and building material may hamper occupation of some otherwise habitable region. However, wherever willow grows abundantly near streams, the beavers accept that plant as a satisfactory substitute for aspen. This national park is unusual in the number of its colonies that have been developed around a dependence upon willow, few of them being primarily dependent upon aspen, as is often the case elsewhere.

A serious problem, especially on streams in the vicinity of Estes Park, is the competitive effect of deer and elk on their winter range upon the supply of aspen and willow. About 1200 elk are in the park, and many of them concentrate near the mountain meadows in winter. At that season they habitually chew the bark from the aspens, and the scars they make provide conditions ideal for the spread of several fungus diseases through the groves, leading to the eventual death of the trees. In addition, the elk graze extensively on grasses near the beaver ponds, and may even eat willow. The mule deer, which number about 1400, also winter on the same range, and browse on the reproductive shoots of the aspen, preventing any important replacement of the dying trees in many areas. The deer forage widely on willows, and also graze, although they eat grass less commonly than do the elk. Together these animals produce a noticeable decrease in the beavers' food supply, which is especially conspicuous in Moraine Park.

On a number of streams, beavers come into conflict with human interests, but such conflicts do not always indicate that there is an overpopulation of beaver in the locality concerned. Most of the complaints received by the park staff are minor, being based upon the cutting of a favorite aspen grove near someone's cottage, flooding of a driveway, or interfering with the supply of water in a well or irrigation ditch. Such problems are usually solved by live-trapping a few animals and transporting them to other regions. On some of the private ranches within the national park a more serious problem is caused by the flooding of pasture lands, and since this damage usually is caused by large colonies of beavers, remedial action is difficult. Another frequent complaint comes from ranchers who operate far below the park boundaries, who suffer from the activities of beavers that have descended the streams and clog the irrigation ditches. These animals are probably crowded out of certain colonies in the park.

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BABY BEAVERS

By T. J. Courtney

Beavers captured my interest as a result of a hobby—16 mm motion picture photography. I have long been convinced that nature subjects, particularly wildlife, offered an absorbing field to work in, and for several years I have used most of my stock in "shooting" any and all wild creatures that came within range of my lens. Because of my admiration for the intelligence of the beaver, and a thought in the back of my mind that a film might be useful at some time to help rescue them from the sickening persecution to which these animals are generally subjected, I have been "gunning" for them at every opportunity. This spring we were privileged to see young beavers, an opportunity, I understand, not enjoyed by many people.

Our first hunt this year (1946) took us to the headwaters of the Tusket River in Nova Scotia. Knowing our interest in beavers, the guide told us that on the night previous to our arrival, May 25, he had heard squeaks in a beaver house half a mile from camp. This lodge had been entirely deserted since the previous summer, and the guide concluded that its current use was due to an emergency. A beaver had recently disappeared from a well established lodge about a mile downstream because, he thoutht, of the heavy traffic of anglers, and had been forced to occupy the deserted house near the camp. In any case, the old lodge had come to life.

On the evening of May 26 we took the canoe in quietly to the edge of the house and could distinctly hear faint and delicate squeaks. Only about 2 feet of the house was out of water. The plaster had been washed away from its dome, and there were merely a few sticks for a roof over the living room. Rain prevented any attempt at filming from May 26 to 29, but during the night of those dates the beavers did cosiderable work to strengthen and thicken the dome of their house, including a little plastering with mud. On Wednesday evening, May 29, just at the sunset hour and in good daylight, we saw an adult beaver ashore near the lodge gathering dry grass and carrying it to the house. On the 30th, light conditions were suitable for color photography.

We approached the house boldly, expecting to hear the familiar splash of a beaver making an exit (the mother, we hoped) but no beaver could be heard to leave the lodge. We quickly removed the thin roof and peered into the living room, but to our amazement no young could be seen. The guide discouraged my wife and me by saying that the mother had carried her young away to another den, that there would be no point in investigating further. However, we sat quietly in the canoe and listened. Shortly we heard the squeaks again, from the other side of the house. The guide investigated and found what he thought might be another living room, but upon opening it proved to be an entranceway. Below him, however, we heard the familiar bubbling sound made when a beaver slips out of a house quietly. Still we could find no sign of either adult or young beaver. I found what I thought was another living compartment on the southwest corner of the house, and upon opening another small hole there, discovered

it was another exit-entrance. The lodge was crisscrossed with tunnels and passages. During this time, three adult beavers swam around in the vicinity of the house, one being a very large animal; the other two were medium sized. I peered inside the hole I had made but could see no young. Suddenly I spied what I at first took to be a small beaver, but closer examination showed it to be the head only of an adult, watching me intently. It was apparently checking to see if we were going to find the young. Its head only was above the level of

FIG. 1. Young beavers about five days old. Note that the eyes are not yet open and that the tail is nearly round. The package of chewing gum is three inches long.

the water in the passageway. The guide then asked me to check with him. He was hearing squeaks again. We soon decided the sounds were coming from a ball of meadow grass, which he had removed when making the second opening in the house. The bundle of grass was lying near his knees. Fortunately he had not thrown it in the lake. To our astonishment, the ball of grass contained four tiny baby beavers (Pl. 1). The bundle had been tucked away in a nook among the sticks near the entrance-exit the guide had opened. It must be that they were carried there for concealment when we were heard approaching the house, and this would account for our not having heard the adult depart. She

was busily engaged in hiding the young in an alcove previously carved out for just such an emergency.

We carried the young ashore in their bed of grass to film them. The sun was bright, steady and warm, and we exposed the babies to the sun only long enough to make each shot. In between, Mrs. Courtney and the guide kept them shaded from the sun and warm with a dry grass covering. During the time we had them ashore their mother (?) was heard crying pathetically from the direction of the house. She apparently was inside searching for the young ones. Her crying was not unlike that of a human being in great distress. It was almost unnerving. The condition of the young, now 5 days old, was not what I had been led to expect. We looked for animals of about one pound each with wide open eyes. Our four babies had their eyes closed, like the newborn kittens of a domestic cat. Instead of weighing a pound or more they were only three to four ounces each. Their bodies measured $3\frac{1}{2}$ inches, and the little tail $1\frac{1}{2}$ inches —5 inches overall from the tip of the nose to the end of the tail. They were fully furred, and the sheen of their coats in Kodachrome film is very beautiful. We neglected to turn back their lips to see if the teeth were formed, and there are a number of other things I suppose we should have checked on, but the cries of the adult were so disturbing we decided that our film coverage was adequate and that the babies should be given back to their mother.

We took them back in their ball of grass to lay them on the floor of the living room. When we approached the lodge we found that the beavers had already begun to repair the damage we had done in opening the house by making repairs from the inside. A large chunk of wet moss had been placed in the opening into the living room. We placed the bundle of kittens and hay on the floor, repaired the holes we had made in the house, and went ashore to get the camera and equipment. We then departed immediately.

When we made a quick, quiet examination of the house the following morning, we were delighted to find it had been thoroughly repaired and strengthened with freshly cut alders and dead sticks. There was one fairly large branch of green leaves included in the material on top of the house, and the living room section had been plastered. We were satisfied the parents had quickly taken over the care of the young, and had decided to remain in the house despite our intrusion. We checked the lodge briefly again on the two subsequent days and could notice further work done on the house, and could hear the kits squeaking. When we paddled off to return to the city it was not without regret that we could not continue our observations.

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CYCLIC BEHAVIOR AND ECONOMIC IMPORTANCE OF THE RATA-MUCA (ORYZOMYS) IN PERU[1]

By Raymond M. Gilmore

Early in 1944, reports of great numbers of a wild rat, *Orzomys xanthaeolus ica*, in certain scattered and farmed river valleys of the barren mountains and deserts of southwestern coastal Peru were received by the Peruvian National Antiplague Service in Lima. First reports came from the departments of Ica and Huancavelica (see map), and a few months later similar reports arrived from the departments of Ayacucho and Arequipa farther south and more inland. The rats were reported as wild and semi-arboreal, and as invading and destroying portions of the cotton, corn and vegetable crops and fruit orchards. Because large numbers of wild rodents living near man may have a grave effect on human health in various ways, these were suspected at first of being a possible direct menace to human life through an outbreak of bubonic plague, especially in the Acari region where plague had been epidemic among the urban "domestic" rats (*Rattus*) in 1940.

In March 1944, Sr. Benjamin Mostajo Patron, Chief Inspector of the Peruvian National Antiplague Service, visited Quebrado de Pisco, Pampano, Huancano, Ticrapo, Huitara, Ocoña, El Ingenio (Hacienda San Pablo), Laramate, Palpa, and Nasca (Hazienda Changuillo) (see map). In all these localities, he found large populations of one species of wild rat that was causing much damage to agriculture.

In May 1944, Sr. Mostajo, the writer, a chauffeur, and a helper, visited Hacienda San Pablo (near El Ingenio), Acari, and Arequipa in the rat-infested zone. While in Arequipa, reports came (May 14) that there was a heavy rat infestation in the mountainous Cotahuasi region, some 250 km to the north, but because the region was inaccessible by automobile and time was short a visit could not be made at that time. It is presumed that the same rat, "rata-muca", was the one reported as so plentiful there.

There appears to be only one species of rodent (*Oryzomys xanthaeolus ica*) involved in these infestations. It is about the size and proportions of the house-rat (*Rattus rattus alexandrinus*), but is not so aggressive. The "rata-muca" is a normal inhabitant of the mesquite thickets and willow and grass margins of the farms in the watered valleys of this otherwise barren region. The only other rodent that was encountered in the same region was the wild cavy (*Cavia aperea pallidior*), a species closely related to the domesticated guinea-pig (*Cavia porcellus*). Populations of the cavy were normal—that is, the animals were not common. The house rat (*Rattus rattus*) is absent from most of the inland area; none was seen, but certainly they are to be found in the larger towns.

The geography of the rat-infested region is remarkable; it is part of the desert area of western coastal South America, an area that extends from extreme southern Ecuador to northern Chile along the coast between the ocean and the

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nearby western wall of the Andes. The deserts become progressively more extreme toward the south until, in northern Chile, they represent some of the most absolute desert regions of the world. The area included in this study, southern Peru, may be described as excessively arid with some winter fogs and rare rains, and the terrain consists of barren coastal mountains and hills with

slightly elevated hard-pan and sand deserts ("pampas"), all of which are dissected by well separated east-west valleys and canyons. Through the valleys, some of considerable size and depth, flow permanent or seasonal streams and rivers that support the only human habitation and most of the animal life of the region. In some of these river valleys, irrigated since pre-Inca times to form areas of high agricultural importance, large populations of humans and animals are concentrated. On the fringes of the valleys, and on some fog-nourished slopes,

exists a scanty natural vegetation. The rare rains are usually of cloudburst character, and generally cause considerable damage to the oasis-like valley agriculture. In the nearby cordillera, rains occur in the summer period, December through May. The region is one of violent seismic activity also. All in all, the landscape is broken and desolate.

RAT ABUNDANCE

Only one locality, Hacienda San Pablo, 3 km west of El Ingenio and about 30 km north of Nasca, was visited long enough to gain an accurate idea of the high population of muca rats and its probems. It is a typical irrigated farm of

PLATE 1

Hacienda San Pablo, El Ingenio; a typical coastal Peruvian river-valley with irrigated fields of cotton, marginal groves of mesquite (normal home of the rata-muca), and surrounding barren hills. Photo by R. M. Gilmore.

about 1300 acres planted mostly in cotton, and situated in a narrow valley among barren rocky hills, 60–75 km from the coast at an elevation of about 500 m. Here heavy infestation of rats caused severe damage.

In a walk from 10 p.m. to midnight over a kilometer or two, on May 4, several dozen rats were seen, all of them in trees, chiefly espinosa (a spiny legume) and willow. None was seen in poplars, which are the usual windbreak trees bordering the plantations. The bark of the espinosa had been gnawed in many cases, but the willows and poplars appeared to be undamaged.

In the following few days many rats were seen as they were driven from their shelters in grass and brush piles that had been ignited by flame-throwers (brush-burners), or when they were brought in dead or alive by the workers, or as they ran about and hid in the thickets of gnarled huaranga (mesquite) trees where the

twisted roots, trunks and branches gave them ample shelter. These huaranga thickets fringed in many places the irrigated river-bottom land, which was planted

PLATE 2

Nest of cotton and cotton bolls, the work of "rata-muca", in a spiny-brush fence at edge of cotton field. Photo by R. M. Gilmore.

almost exclusively to cotton, with some few fields of corn and some orchards of orange and grapefruit. The principal rat damage was to cotton, which had been removed in the bolls by the rats, carried to the edges of the fields, and there

stripped of the seeds. Wire and brush fences in some places were packed with cotton, much of which had been carried above ground to storage nests, which were sometimes used by the rats also for sleeping quarters.

The only successful control measures tried here seemed to be brush and grass-pile burning with flame-throwers, and persecution by the workers, their children and dogs. Every evening about 200 dead rats were brought to the main ranch by some 25 workers and children, and other rats were brought to other centers on the farm, for each of which one "real", or 10 centavos, was paid. The total weekly catch averaged about 1500 to 2000 rats during the month of May. About half of them were adults. Of the remaining half (young specimens), about half were juveniles from the nests. The proportion of the sexes was about equal. No accurate figure can be given for the density of the rats, but an estimate of 100 per acre (250 per hectare) is probably close.

Several days were spent also in and around Acari which is near the coast between Nasca and Chala. Here the rat increase was "spotty"; some farms suffered severe damage while others escaped injury. A search was made at night at Chavina, a farm at the mouth of the Río Lomas which flows through Acari (some 20 km inland) to the sea at Chavina, but no rats were seen in the heavy willow thickets. Next morning, however, about a dozen were taken from under grass and brush heaps on the edges of the cotton fields. The rata-muca here was not as abundant as farther north.

Arequipa also was visited for a few days, but no rats were seen in searches through the likely spots of the upper Río Chili canyon, although two wild cavies (*Cavia*), which usually are less common and harder to catch than the rats, were found.

There were no apparent mass movements of rata-mucas over long distances in any direction. Any movement probably was confined to pushing toward the center of each cultivated valley (source of more food) by the multiplying populations on the margins. The rats did not seem to have pushed out over the adjacent barren country, probably because of the long distance to the next valley and the hot, dry conditions.

The increase in numbers of the rata-muca in 1944 seems to have started late in the summer of 1943 and was still in effect at the end of May 1944, declining late in the same year. Other "rat-years" are well remembered by the local inhabitants, and Sr. Umberto Elias, Gobernador of El Ingenio (3 km from Hda. San Pablo), listed the following "bad rat-years" from memory as follows:

1907—High population of rats; serious destruction of crops.

1926—High population of rats; serious destruction of crops; this increase and infestation followed soon after the famous "year of the rains", 1925, and was easily remembered.

1939—High population of rats; like 1907.

1943–44—High population of rats; like 1907, which evidently was truly a "bad year".

From May 1944 to May 1945, the numbers of rats decreased to a few isolated scattered colonies (letter from Rualde Martinez, Hda. San Pablo, May 16, 1945).

Occucáje, a grape and wine producing center about 100 km northwest of El Ingenio, is said to have suffered severely from a rat plague about 30 or 40 years ago, at which time many cats and dogs were bought, borrowed, or stolen from surrounding areas to combat the rats. This would indicate that the rat infestation was local at that time.

The large collections of Inca and pre-Inca pottery in the museums of Lima have many incised representations of rats gnawing ears of corn. The size of many of the figured rats would indicate that they were identical with the present rata-muca; others are of mouse size, indicating a smaller species, perhaps the small *Phyllotis andium* or *P. amicus*. The relative abundance of these pottery figures of rats would indicate also that such rat depredations on corn fields and granaries were common and important enough in aboriginal times to make the Indian inhabitants highly conscious of them.

From the above statements, it seems reasonable to conclude that these peak populations of rata-muca in southwestern Peru, with consequent agricultural loss, are cyclic. Some of the peaks have been higher (more rats) and hence worse (more agricultural damage), and thus more noticeable. However, there appears to be no accurate written record of such cyclic increases in historic times, or even in the last 50 years or so. The cycles appear to be quadrennial.

The causes of periodic fluctuations in the Peruvian rata-muca are unknown. Periodic fluctuations of other rodents have been recorded in southern Chile (Philippi, 1879) with the time between peaks 15–25 years (species not given), and in southeastern Brazil (Derby, 1879; Pereira, 1941) with highs each 30 years for the rodent *Oryzomys longicaudatus* and some other species, particularly *Rattus rattus*. In these cases cyclic fluctuation have been attributed to the concurrent or slightly previous (year or so) flowering of bamboos ("coligue" in southern Chile; "taquara lixo", *Merostachys fistulosa*, in southeastern Brazil). Strangely, Tschudi did not record cyclic rat plagues in Peru in his account of the mammals of that country (1844), although he does mention (p. 184) that *Rhipidomys leucodactylus* of the eastern jungle was a "Plage" in the corn and yucca (mandioca) fields, but this can mean mere continual abundance with agricultural damage. Nor did Tschudi collect the rata-muca in his visit to the Ica region. Hudson (1903) noted a sudden increase in "mice" to astonishing numbers on the La Plata pampas in 1872–3, with scarcity again by August, 1874.

Heavy growths of a small cane-like bamboo were noticed along the water courses at Hacienda San Pablo. Most of them appeared dead, so they may have flowered a year or so previously. No association with the rat increase can be affirmed in this case, however. The local inhabitants do not seem to associate the rat increases with anything except the subsequent agricultural loss. There had been no recent noticeable climatic cause that might have been responsible.

Periodic fluctuations of mammals (and birds) occur in several species in the northern hemisphere. Voles (*Microtus*) and Lemmings (*Lemmus*) are famous for their four-year cycles of abundance, which are accompanied, in the case of lemmings of Europe and North America by migrations in countless numbers over mountain, tundra and river, to the sea, into which they plunge and die by the

millions. Northern hares (*Lepus*) and associated predators, such as the lynx (*Lynx*) and red fox (*Vulpes*), have a 9 to 10-year cycle. The ruffed grouse (*Bonasa umbellus*) also has a 9 to 10-year cycle. As yet no adequate explanation of such cycles of population has been given, although the sunspot cycle of 11.2 (7 to 17 years) has often been advanced. Perhaps the explanation will be found to be related to a biologic rhythm which is inherent in the species involved; perhaps it is partly dependent on a biologic rhythm of a parasite or an epizootic disease because a specific disease epidemic accompanies the sudden decrease in numbers of some cyclic species (see Elton, 1924; Huntington, 1932). The biologic rhythm of population cycles itself may be an adaptation for success in evolution, because abundance permits greater plasticity through a larger "reservoir" of heritable variation, both actual and potential, with possibilities for a noticeable slight change in the populational characters afterwards (see Huxley, 1942, for a summary of the work of others, particularly E. D. Elton, S. Wright, and E. B. Ford).

The cycles of the northern forms have been studied thoroughly by many investigators, and ably summarized by Elton (1924 and 1942). The mechanics of a normal cycle seem to be as follows: Low numbers,—slow increase—sudden increase to peak—and sudden drop again to low numbers. The abrupt sudden drop has been shown in the case of voles, hares, foxes and grouse to be accompanied by specific epizootic diseases. Hence, it was expected that the Peruvian rata-muca increase and abundance of 1944, beginning in late 1943, should show a marked slump in late 1944, and that such sudden decrease in numbers might possibly (probably?) be the result of an epizootic disease. The slump occurred; but there was no evidence of any disease in March or May 1944, either in fresh autopsies, tissue-cultures from rats found dead, or in tissue-cultures from fresh autopsies. No study was made of the other possible causes of decrease.

The presence of 10 to 25 lelapid ticks on almost every rat examined might indicate a possible ectoparasitic check on high populations. Although it may be doubted that the ectoparasites themselves could cause death and thus a decline in the population, they surely would aid in the demise of individuals that are weakened by disease or lack of food. Thus the cumulative effect of many ticks coould be considerable.

A condition of special interest in this Peruvian rat increase is that the earliest reports (March) were from northern localities (Pisco-Ica-Nazca), while later reports (May) were from farther south (Cotahuasi). There was no marked increase south of Acari on the coast nor south of Cotahuasi in the mountains. This indicates a circumscribed geographic limit to the phenomenon, and a southward trend in time of the high populations, which, however, seems to have been higher in the Nasca-Ica region than elsewhere.

Another interesting fact is that, contemporaneous with the rat increase, there was an increase in numbers of parrots, with accompanying agricultural depredations, in several nearby localities higher in the Andes and farther north (at Andahuailas and Chincheros). The large number of parrots caused considerable damage to corn crops, and their abundance was said to be of cyclic

occurrence. None of these large flocks was seen by our party, and no specimens were obtained, but it is presumed that they were invaders from the east—from the central Peruvian Valley of the Apurimac River, and not from the altiplano farther south. Hence they may be presumed to have been individuals of a species of the medium-sized parrot from the eastern mountain forest, an *Aratinga*, probable *A. wagneri*, and not the small rock parrot of the altiplano, *Psilopsigon aurifrons*. On occasions the parrot *Aratinga wagneri* has been known to make its way to the coast, whence specimens have been reported as collected at Lima and Pisco Valley. The parrot increase thus involved considerable movement, which is a logical result of suddenly increased numbers of a highly active and motile organism. The movement of the rata-muca, however, was confined to small scale invasions of the plantations and crop storages from the nearby fringes of each afflicted valley.

ECONOMIC CONSIDERATIONS

Public health.—As yet, no public health problem has been shown to be associated with the high rat population. After the early reports of March, it was believed that bubonic plague might break out, especially in the Acari area where the disease occurred but was quickly suppressed, in house rats (*Rattus*) and humans in 1940. No evidence of bubonic plague was found either in fresh autopsies, fresh tissue cultures, or in tissue cultures from a few rats that were found dead; nor was there evidence of any other disease.

Bubonic plague has been established on the coast of Peru and at a few inland stations on the west side of the Cordillera since 1903, but it has not been common south of Pisco. One of the few southern outbreaks was at Acari in 1940 (others were at Camaná, Mollendo, and Ilo in earlier years). Today, bubonic plague is confined mainly to the north coast—Pisco, Lima, Callao, Chimbote, Trujillo, Chiclayo, etc., north into Ecuador. The climatic factor of fewer winter fogs south of Pisco may be operative; the rat flea (*Xenopsilla cheopis*) requires a great deal of humidity as well as an optimum temperature. However, it is strange indeed that bubonic plague has not yet become established in any wild rodent in Peru, especially since wild cavies (guinea pigs) live throughout most of these regions, and the domestic guinea pig is one of the most susceptible of animals to *Pasturella pestis*, the causative organism of bubonic plague.

Sylvatic plague in the absence of house rats is thought to exist in Peru in the high Cajamarca region. From Raquia, southern Ancash, where plague occurs with *Rattus* rats, a wild plague-rat suspect which proved to be *Oryzomys xanthaeolus baroni* has been received recently from the Peruvian Anti-plague Service and the Panamerican Sanitary Bureau. This is a northern and high mountain subspecies of the rata-muca. Sylvatic plague, without *Rattus*, probably occurs in Bolivia in the vast southeastern high plateau (around 2000 meters) lying south of the Sucre-Santa Cruz road, north of the Azero River, west of the Chaco, and east of the eastern Andean Cordillera (eastern boundary of the high altiplano). Evidence suggests also that sylvatic plague occurs in northwestern Argentina and northeastern Brazil (see reports by Moll and O'Leary, 1941; also Macchiavello, 1941).

Agriculture.—Extensive damage was inflicted by rats on agriculture. Losses might have run as high as 20 percent in certain places, but no accurate estimates based on land area, produce measure, or tree and plant counts were made.

Cotton probably suffered most. It is the principal crop of the afflicted region, and was ripening in March to May (late summer and early fall) during the peak of the rat population. The rats must have climbed the bushes and cut off the bolls, for the latter were carried to the edges of the fields and piled in storage nests or strewn about in the bushes and trees. The seeds were eaten. Great quantities of cotton were thus harvested by the rata-muca and lost to the farmer.

Loss in corn was probably the next heaviest, and depredations were committed by rats in the fields as well as in storage bins that were in and around the ranch houses. Orange, grapefruit, and apple trees, as well as grape-vines, suffered considerably through girdling near the base and by bark-gnawing on other parts of the plant. Sweet potatoes and other subterranean vegetables were damaged. The rats apparently dug in the ground for the tubers and roots.

Control.—Control measures in Peru in this 1944 rat peak were difficult. Poisons were ineffective, and only brush burning with constant persecution by men and boys with clubs and by dogs showed any yield of dead rats, and then it is doubtful whether this slaughter had any appreciable effect in reducing the high population.

Natural predators—hawks, owls, opossums, weasels, foxes—were scarce, and apparently did not increase during the height of the rat cycle. Their control effects consequently were low. Of these listed predators, only a few hawks were seen.

Poisons such as arsenic-trioxide (soluble) in flour, barium-carbonate on bread and corn, and "Liverpool Virus" on bread and corn were used more than any other agent in control. All proved equally ineffective. There appeared to be such an abundance of natural food that poisoned baits were not quickly accepted by the rats, if at all.

The question of poisons is an important one because of their low cost and the ease of treating large areas. However, some poisons are extremely lethal and kill every living thing that ingests them; others are not lethal enough, or are too bitter in taste to disguise. None is specific, although such a one possibly may be prepared from a pathogenic organism of the rata-muca during an epizootic. But if experience is a guide, even this would not be effective in control.

The "bacteriologic" method of control is discussed and considered unproven or inefficient by Rosenau (1910), Galler (1935), Elton (1942), and Leslie (1942). The method is considered efficacious under certain limited and favorable circumstances by Antonovskii (1931), and Dmitrevskaya (1931). For the isolation of various epizootic agents, see these papers and also Suknev, Chizhova and Kazantzeva (1933), and Stupnitzkii and Tinker (1935).

The rata-muca increases and infestations in south coastal Peru are thus natural unavoidable phenomena, and of immediate agricultural rather than public health importance, although the latter should not be forgotten in this country where bubonic plague is endemic. The periodic increases and subsequent depredations are to be looked upon in the same light as periodic floods, tornados, insect infestations, etc. The afflicted farmer should be forewarned and forearmed to combat

the rats by early brush-cleaning and burning, early planting and harvest, the construction of rat-proof storages for his produce, and early use of effective poisons. The rat-year can be anticipated by knowing the cycle and watching for signs of increasing population during critical years. The protection of fruit trees is more difficult, because any guard around the trunk, except a complicated and expensive tin or galvanized iron one, could be climbed by this large rat.

SUMMARY AND CONCLUSIONS

In early 1944 in south coastal Peru a sudden high increase in numbers of a wild rat ("rata-muca," *Oryzomys xanthaeolus ica*) occurred. The region is arid and barren, and inhabited by man and animals in scattered oasis-like river valleys that are rendered habitable and of high agricultural importance by seasonal and permanent water for irrigation. The increase of rats is probably a regular cyclic phenomenon and some of the peak populations are extremely large.

Destruction to agriculture was the principle economic problem in this Peruvian rat infestation. Public health problems, especially in relation to bubonic plague, were not demonstrated. Control measures were difficult and involved brush-burning and persecution by humans and dogs, as well as the less successful use of poisons. Natural predators were scarce, and those present were not effective in control. The only other rodent seen in the region at the same time was the wild cavy or guinea pig, (*Cavia aperea pallidior*), which was present in small numbers.

The rata-muca (subspecies *ica*) is a large wild rat, with the approximate size and proportions of the house rat (*Rattus rattus*), that probably ranges from the Pisco-Ica area southward to the Chala-Cotahuasi region. It is both terrestrial and scansorial, and normally lives in mesquite groves and grass and brush thickets on the edges of the cultivated fields.

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NOTES ON COMMENSAL RATS IN LAVACA COUNTY, TEXAS

BY DAVID E. DAVIS

The observations of commensal rats here reported were obtained while studying the results of various measures to control typhus fever. The causative agent of typhus fever is carried from rat to rat by fleas. Human beings also are recipients of the infection from rat fleas but the details of the transmission are not clear. Control of the disease consists of eradicating rats by poisoning, trapping, and rat-proofing buildings and obviously a thorough knowledge of the habits of rats is necessary for successful control. Although there is a voluminous literature about rats and disease, very little exists concerning the habits of rats in the rural areas of United States. This paper is intended to record the observations on rural rats in Texas for comparison with studies in other areas. There

is no attempt at this time to compare these notes with the numerous observations upon urban or ship rats.

These investigations were conducted in Lavaca County, which lies in southeastern Texas about 100 miles from the coast. The human population is about 25,000 of which 5,000 live in Yoakum, 2,000 in Hallettsville, 1,000 in Shiner and 700 in Moulton. In addition to these four towns, there are also 12 unincorporated communities. The county may be divided into three soil and vegetation type areas. The southern third of the county has sandy soil and is used for grazing. The central third has sandy loam and produces good crops of corn, peanuts and tomatoes. The northern third has black soil and was formerly devoted to cotton but now grows corn and sorghums in addition.

The rats were collected between January and October 1945. They were caught in number 0 steel traps and brought to the laboratory alive in sacks. They were then bled, combed for ectoparasites, measured and sexed; the data were recorded on punch cards.

The Norway rat (*Rattus norvegicus*) was found only in the town of Yoakum. A few were collected there in January and February but control activities soon practically eliminated the species. The few observations obtained showed that these rats lived principally on the ground floor, burrowed only in certain places and were most common in grain and poultry stores.

The roof rat (*Rattus rattus*) is present throughout the county in the towns and on the farms. In coloration the individuals resemble the race *R. r. frugivorus*. However, several typical black *R. r. rattus* were captured in the town of Shiner and many intergrades exist between the subspecies *rattus*, *alexandrinus*, and *frugivorus*. Since there appears to be no difference in habits, the subspecies as such will be ignored and all rats called roof rats.

Roof rats inhabit grocery and drug stores, warehouses, theaters, and poultry stores and are very common in the cotton gins and associated grain warehouses. On the farms they live in barns and corn cribs but no rats were ever found in farm houses, although farmers say that rats come inside once in a while.

The roof rats may live near the ground but usually they frequent the rafters and cross beams. They make typical runways along pipes, beams or wires and up and down the 2 x 4s. In the corn cribs, the rats run along the horizontal 2 x 4s and often leave a layer of grease and dirt, and also consume great quantities of corn and grain. They gnaw wood frequently; in one barn the rats gnawed two beams, 2 x 8 inches, completely in two, without any apparent reason.

The breeding season of roof rats has been studied by determining the percentage of the age classes in the different months (Table 1). The age classes for this study are based upon the reproductive condition, not upon size or ossification of the skull because the important aspect from the disease viewpoint is whether the rat is reproductively mature. Thus three age groups were determined. The young rats have small testes and seminal vesicles or infantile ovaries and threadlike oviducts. The subadult male rats have medium sized testes with an obvious artery and seminal vesicles about 5 mm long. The subadult female rats have follicles in the ovary and white wide oviducts. The adult

TABLE 1.—*Monthly percentages by age and sex of roof rats in Lavaca County, Texas*

SEX AND AGE	JAN.		FEB.		MAR.		APR.		MAY		JUNE		JULY		AUG.		SEPT.	
Males																		
	Rats	%	Rats	%	Rats	%	Rats	%	Rats	%	Rats	%	Rats	%	Rats	%	Rats	%
Adult	13	52	28	70	40	55	63	69	52	64	63	59	72	77	39	85	23	52
Subadult	5	20	5	13	9	12	15	16	12	24	19	18	13	14	6	13	10	23
Young	7	28	7	17	24	33	13	14	10	12	24	23	8	9	1	2	11	25
Total	25	—	40	—	73	—	91	—	81	—	106	—	93	—	46	—	44	—
Females																		
Adult	17	74	18	45	34	48	68	53	75	55	76	61	66	58	46	69	17	45
Subadult	1	4	12	30	15	20	27	21	26	19	28	22	27	24	13	19	15	39
Young	5	22	10	25	23	32	34	26	35	26	21	17	21	18	8	12	6	16
Total	23	—	40	—	72	—	129	—	136	—	125	—	114	—	67	—	38	
Pregnant	3	17	4	22	8	24	7	10	24	32	21	28	8	12	1	2	7	40
Males & females	48	52	80	50	145	50	220	41	217	41	231	46	207	45	115	40	84	52

TABLE 2.—*Head and body length of roof rats in Lavaca County, Texas.*

AGE	SEX	TOTAL RATS	MEAN IN MM.	STANDARD DEVIATION
Adult	Male	245	164.97	14.7
	Female	301	164.99	12.9
Subadult	Male	72	145.04	14.5
	Female	106	135.55	16.3
Young	Male	57	115.40	14.9
	Female	138	115.28	15.3

TABLE 3.—*Length of pregnant roof rats*

SIZE IN MM.	FEMALES EXAMINED	NUMBER FEMALES PREGNANT	PREGNANT PERCENT	TOTAL EMBRYOS	ARITHMETIC MEAN
110–119	25	0	0	—	—
120–129	46	1	2	6	6.0
130–139	53	1	2	7	7.0
140–149	73	13	18	85	6.5
150–159	72	15	21	99	6.7
160–169	113	39	35	275	7.0
170–179	60	22	37	139	6.3
180–189	40	5	12	38	7.6
190–199	3	3	100	22	7.1
Total	485	99		671	6.8

male rats have mature testes and large convoluted vesicles. The adult female rats have old corpora lutea and placental scars or are pregnant.

It is obvious from Table 1 that reproduction may occur in any month of the year. There appears to be a maximum number of young in January, February, and March and a minimum in July and August. The increase in percent of pregnant females in September suggests recurrence of breeding in the fall.

The size of roof rats is given in Table 2. The length of head and body is used because the tail is so frequently broken off. It is clear that there is no difference in size between the sexes. The figures for young rats refer obviously only to rats caught in traps. The size at sexual maturity and the number of embryos are given in Table 3, which shows that the females reproduce at about average size. An average of 6.8 embryos per litter is not high.

The sex ratio for the age classes are given in Table 4. The ratio for adult rats is about equal, but more subadult and young female rats were captured. In the total population the ratio is in favor of females. It is also noteworthy that adult males are relatively more common than adult females. Possibly this

TABLE 4.—*Sex ratio of age classes*

	ADULT		SUBADULT		YOUNG		TOTAL
	Rats	%	Rats	%	Rats	%	
Male	393	65.8	101	16.8	105	17.4	599
Females	417	56.2	164	22.0	163	21.8	744
Both sexes	810	60.3	265	19.7	268	20.0	1343
Percent male	48.5		37.8		39.4		44.6

indicates a greater length of life in males if we assume equal birth ratios and mortality of young.

SUMMARY

Commensal rats were studied in Lavaca County, Texas, from January 1945 to October 1945 in relation to the control of murine typhus fever. The Norway rat (*Rattus norvegicus*) occurred in only one town. The roof rat (*Rattus rattus*) occurred in all towns and on farms. It inhabits stores, warehouses, barns and corn cribs.

Roof rats breed throughout the year but reach a maximum in February and March and in May and June and a minimum in July and August.

The sexes average the same in length of head and body (164 mm). The females begin breeding at a length of 125 mm and reach a maximum at 165 mm.

The sex ratio of adults is about equal but for subadults and young it is in favor of females. There is a higher percentage of adults among the males than among the females.

A CONTRIBUTION TO THE KNOWLEDGE OF THE CAMBODIAN WILD OX OR KOUPROH

By Francois Edmond-Blanc

After the work of the Eighth Expedition to Indo China under the leadership of J. Delacour was finished in March 1939, I went to the eastern part of Cambodia to make an effort to clarify the problem of the little known Bovidae of that region, of which I had heard during a previous trip to Indo China in 1930. Previous to 1939 we know the following about the kouproh: (1) An oral description given by M. Omer Sarraut in the course of a lecture in the Grand Amphitheatre of the Museum National d'Histoire Naturelle in Paris in 1935. (2) A calf, brought back alive to the Vincennes Zoo in Paris by Professor Urbain in 1937. This specimen was captured by agents of the government of Cambodia. Unfortunately it died at the beginning of the war before reaching maturity. (3) A mounted head given by M. Sauvel, a veterinarian of Cambodia, to Professor Urbain, who presented it to the Museum National d'Histoire Naturelle. Unfortunately this skull was covered with the skin of a domestic bull when the specimen was mounted by A. Pietri, a taxidermist at Saigon.

Professor Urbain described this animal as new to science in the Bulletin of the Zoological Society of France in 1937, giving it the name *Bibos sauvelli*, and later, in 1939, he designated the living specimen at the Vincennes Zoo as the type of this new species. In view of the fact that little or nothing was known of the animal, the first scientific work on the subject was perhaps premature. It was with this in mind that I went to Cambodia in 1939 to collect a complete specimen, which was the first entire specimen collected for serious scientific study.

For this purpose I addressed myself to A. V. Pietri, a professional hunter and taxidermist of Saigon, who was the first European to see this strange animal and to recognize its distinct characters. We left Saigon for Cambodia in the beginning of March. Not only did I wish to collect a specimen of this animal but also I was anxious to study the habits of the living creature. It lives in open forest without underbrush in the eastern part of Cambodia. Almost all the rivers are dry at that season, so that the little water that remains is in muddy wallows. The few rolling hills are covered with forest somewhat more dense than that of the valleys. It is an extremely hot country, the average temperature being about 35°C.

Whether or not this form is a valid species is somewhat questionable and I have not been able, as yet, to reach a satisfactory conclusion. I have taken as a basis for these notes the specimen which I myself collected and which Mr. Coolidge described (Memoirs Mus. Comp. Zool. 1940) as *Novibos sauvelli* (Urbain). Incidentally I certainly cannot agree that this specimen is generically distinct from other members of the family.

Natives call the animal "Kouproh", whereas they call the calf collected by Prof. Urbain "Kouprey." They say that the difference lies in the manner in which the horns turn. The kouproh has the horns turned slightly more inward.

PLATE 1

Views of the kouproh. Note the enormous dewlap, the "shredded" horns, and the white "socks".

Furthermore the color, according to them, is greenish grey rather than off white as in the kouprey. Are there really two different forms, or is the kouprey only a young kouproh? We do not know! Is the kouproh a species or is it a hybrid? I believe it to be a hybrid for the following reasons: (1) According to Pietri and natives, males and females of the kouproh have never been seen together; (2) I myself have seen one single kouproh on one occasion and two individuals on two different occasions together with herds of banteng. When I disturbed them and the herds fled, the strange animals remained with the banteng; (3) according to the natives the young ones have never been seen with the females. The young kouproh resembles closely the young banteng; (4) even though the range is large, the animal is not common in any part of it.

If we assume that this is a hybrid population, then these are the five important points: (1) the kouproh is found very often with herds of banteng but is differently colored, has no light rump patch, nor is there any horny tissue between the horns. Furthermore the kouproh is much larger than the banteng; (2) it resembles the gaur in the shape of the hoof, the presence of white socks, the size and the presence of the hump which last is remarkably developed; (3) the dewlap resembles that of domestic cattle of Indo China; (4) the habits and the shape of the head are like that of a water buffalo; (5) the kouproh is found only in this region in which these four species are found together.

I myself have observed that its habits are those of the water buffalo. During the seven hours that I followed the animal that I finally was able to shoot, he wallowed in every suitable spot that he could find along the way. It is well known, and it has been my personal observation, that neither the gaur, the banteng nor the domestic cattle of the region ever wallow in this manner.

Another remarkable peculiarity that I observed of the habits of the kouproh was that it put its horns into every termite's nest that it passed. And a third characteristic and unique habit was that of turning up the soil with the horns and this apparently is the cause of the shredding of the horn sheath, leaving a very striking "pom-pom" surrounding the tip of the horns of mature males; the sharp point of the horn projects from what appears as a kind of necklace. This phenomenon appears in males about the seventh or eighth year, according to the natives. They say also that the animal puts his horns into the termites' nests in order to eat the termites, but this cannot be believed. The stomach of the specimen that I collected contained only grass and bamboo shoots. It was apparent from the tracks of the animal that I followed that it does not stop to eat at the termite nests but only throw a horn into them in passing, for it never put its legs together as it would have done if stopping to eat. It has been suggested that when the animals turn up the soil with their horns that they are looking for roots, but I have examined these places and never found any roots. It appears possible, therefore, that they turn up the soil in this way in order to sharpen their horns and that in the process the horns are shredded. They continue to do this in order to keep the exposed point sharp.

Let us now examine the possibility of hybridization between any two of the four species of bovids inhabiting this region.

Gaur x *Banteng*.—I myself have seen a female gaur together with a calf in

the midst of a herd of banteng. Pietri has told me that on several occasions during his many trips into the region he has seen four female gaurs in herds of banteng. He believes that they were the same individuals. As I have said before, the kouproh and gaur resemble one another in the shape of the hoof, the presence of white socks, and the size and presence of the hump. Against the hypothesis of a gaur x banteng hybrid are the following points: Why should such a hybrid have the habits of a water buffalo? Why should it have the enormous dewlap which appears in neither the gaur nor the banteng but which is so apparent in the domestic cattle of the region?

Banteng x *Water Buffalo.*—In this particular area in eastern Cambodia, water buffalo inhabit the same region and the same particular territory as banteng. Although I have never seen these two species actually together in the same bands or herds, I have seen individuals of the two in close proximity to one another, and this is not possible in any other region of which I have knowledge. As I have said, the kouproh has some of the same habits as the water buffalo. The hoofs of the kouproh are smaller but they are shaped like those of the water buffalo. The shape of the head, the color of the skin and the manner in which the hair is worn off and abraded on the sides is alike in kouproh and water buffalo. The horny sheath of the horn of the banteng and the water buffalo are of an entirely different constitution; a mixture of the two might possibly be the cause of the shredding of the horny sheath. Against this hypothesis of hybridization of water buffalo and banteng we have the hump of the kouproh which is not a character of either the water buffalo or the banteng.

Banteng x *domestic cattle.*—The dewlap and the shape of the head resemble those of domestic cattle. But against this we have the larger size of the kouproh and all the other special characters mentioned above.

Since the animal apparently lives with the banteng, it is probable that the banteng must be considered to be one of the parents and, therefore, it is not necessary to consider the three other possibilities *i.e.*, gaur x water buffalo, water buffalo x domestic cattle, gaur x domestic cattle.

In regard to the female of the kouproh, I should like to say only that it resembles in general form and appearance the female of the banteng but the color is pale, uniform grey with a black stripe down the middle of the back. The horns are characteristically curved like a lyre. It must be said here that I have seen females on one occasion only, and then through glasses at a distance of 100 meters. At that time there were eight together without males or other Bovidae nearby. Even though I saw females only once, still I followed their tracks on many occasions and I never found tracks of males with those of the females. On several occasions I found the tracks of males cutting across the tracks of females, but never was it apparent that the males had made any attempt to follow.

It will be necessary to spend several months in the country in order to observe the habits of this curious animal and also to collect more specimens in order to formulate a better opinion. Furthermore, in this case, where the biological entity of the form as a species is in question, much more information on the status of the population, as well as its habits, is unquestionably necessary.—*Cambridge, Massachusetts.*

A KEY TO THE RODENTIA INHABITING INDIA, CEYLON, AND BURMA, BASED ON COLLECTIONS IN THE BRITISH MUSEUM

By J. R. Ellerman

Part I

This work is the result of more than a year's study of Indian rodents, based upon the very extensive collections of the British Museum. It is the first general revision attempted since Wroughton's summary was published in 1919. In order to arrive at the conclusions offered here it has been found necessary to study all rodents in the British Museum from the whole of Asia, Europe, North Africa, and Australia, and detailed notes have been taken on more than 13,000 specimens, including measurements of all unbroken skulls available in the London collection.

When one is dealing with such very large numbers of specimens, it soon becomes clear that supposed differences between subspecies, and indeed often between closely allied species, must of necessity become average rather than absolute. I have, however, in dealing with Indian material, retained all subspecies previously named where there seemed the least excuse for so doing. Probably several forms retained in the present work will ultimately disappear into synonymy, as more material comes to hand. If two species occur together in many places, they are here in general given specific rank, even if individually they sometimes cannot always be distinguished. In Indian territory, it should be noted that there are many named races of rats and squirrels from the various islands of the Mergui Archipelago. Although in the past it has been fashionable to consider each small island form as a named subspecies, in my opinion it is highly unlikely that a lot of these insular forms can be retained as valid. I have been fortunate in having in my possession a valuable collection recently taken by Mr. W. J. C. Frost from Sind, Assam, and Manipur. Results obtained from this collection have been included in the present paper.

I have based my arrangement on the keys of Vinogradov in his rodents of the U.S.S.R. and his various papers on the Family Dipodidae. I have numbered the species continuously from 1 to 115, and the subspecies from 1 to 266 in the key. All references, with two exceptions, both of which are given here, and all type localities will be found in my former work, *The Families and Genera of Living Rodents*, 1940 and 1941. For each subspecies examined I have listed the localities whence specimens were taken, as well as the approximate number of specimens examined. These numbers are approximations because I kept no notes on skins lacking measurements, and for each species there were several broken skulls that could not be adequately measured. Many of the localities listed here, particularly from Kashmir or Nepal, had not been spotted by me on any map, at the time of writing. These place names were copied from the skin or skull labels. Some of them are illegible, and may not be spelled correctly. I suspect that some of these obscure places are native villages or perhaps gardens or plantations which would not normally appear in atlases.

Regarding cranial measurements, the *occipitonasal*, which is the main measurement taken for all species, is from anterior tip of nasal to back of occiput, or to center of top of occiput when this projects or slants backwards behind the lambdoidal region, errors, if present, tending to be on the large side. The palate is measured from the front of the incisors to the back of the palate, ignoring the spinous process if it is present; the diastema, from a point immediately behind the front incisor to a point immediately in front of the front cheektooth; the palatal foramina, from a point immediately in front of the foramina to a point immediately behind it; the bullae length, from a point immediately next to the paroccipital process to the nearest point opposite the inflated part of the bulla, not including the mastoid portion when it is swollen, as happens in Dipodidae or Gerbillinae. The toothrow is the crown length of upper toothrow; frontals width is the least interorbital width. The orbit, used extensively in Sciuridae but not elsewhere, is from the lachrimal to a point on the posterior zygomatic root just after this has left the squamosal. The occiput, used only in subterranean rodents like Rhizomyidae, is from top of foramen magnum to top of lambdoidal ridge; the condylobasal, from the occiput to the front of the incisor. All measurements given in the key will most likely alter slightly as large numbers of specimens come to hand for each subspecies. When I state that *Petaurista petaurista lanka* has a frontal width usually exceeding 18 mm, thereby differing from *P. p. phillippensis*, which most often is less than 17 mm, I do not expect that these figures would hold if really representative material was at hand, but that these two forms would most likely differ from each other racially in proportionately wider or narrower frontals, as the case may be. All measurements for skulls quoted in the key have been carefully checked. No named form not represented in the British Museum is included in the present work.

Although it will be found that the results in this preliminary account differ widely in certain respects from those arrived at by Wroughton, it should be realized that the work now done has been rendered possible by the very great efforts made by Wroughton to bring together in London a really representative collection of Indian mammals, and it is not too much to say that no work would be possible today without the use of the magnificent collections brought together by the work of the Bombay Natural History Society's Mammal Survey of India. Quite apart from Wroughton's pioneer work as a mammalogist, the inception of the Mammal Survey was entirely due to his imagination and to the joint activities of himself and of Mr. W. S. Millard.

KEY TO THE RODENTS OF INDIA, CEYLON, AND BURMA

1. (10). **Lower jaw specialized by distortion outwards of angular process by specialized limb of masseter lateralis superficialis; infraorbital foramen much enlarged for muscle transmission, and zygomatic plate remains completely below it; fibula unreduced, not fused with tibia; premolars not reduced in size, cheekteeth (4/4) flat-crowned, their pattern formed by inner and outer re-entrant folds. Skull broad, with unconstricted frontals. Fur modified into spines or quills or a mixture of both, the tail entering into the general spiny modification. Five toes on hindfoot. Large animals, occipitonasal length in Indian specimens usually exceeds 100 mm, and can be as much as 161 mm. . . .(2).**

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2. (5). Nasals short, confined to rostrum, not widened, and usually less than 30% of occipitonasal length, or at most approximating to this percentage, in length, not exceeding 29.4 mm; tail long, varying from third to half of head and body length; end of tail bears cluster of highly modified, alternatively expanded and contracted bristles; spiny covering at lower degree of specialization, with no true quills on back in Asiatic species; occipitonasal length approximates 100 mm at highest, but in Asiatic specimens is usually less; anterior zygomatic root situated approximately over premolar.

Genus ATHERURUS Cuvier, 1829

There is only one species in Asia.

Species 1. *ATHERURUS MACROURUS* Linnaeus, 1758.

3. (4). Upper toothrow in adult skulls with M^3 fully cut not less than 17.8 mm. 1. *Atherurus macrourus macrourus* Linnaeus, 1758. Typically from Malacca. One Indian specimen, from Thoungyeh, Tenasserim, and others from extralimital localities, have been examined.

4. (3). Upper toothrow about 16.1 mm in length.

2. *Atherurus macrourus assamensis* Thomas, 1921. The type, from Cherrapunji in the Khasi Hills, Assam, has been examined.

5. (2). Nasals long, inflated, not confined to rostrum, widened to certain extent, and in Indian species usually approximates half of occipitonasal length, or slightly less, at lowest; in length not less than 57.3 mm, usually more than 60 mm; tail short, less than one fifth of head and body length in majority of measured skins available; end of tail bears cluster of highly modified hollow "rattling-quills"; the spiny covering highly specialized; true quills always present on the back; occipitonasal length not less than 117.5 mm; anterior zygomatic root situated further backwards, approximately over middle of toothrow.

Genus HYSTRIX Linnaeus, 1758

6. (9). External spiny covering less specialized; no crest of hairs on head, or this poorly developed and weak; main quills on back mostly white terminally and basally, and always with one dark ring in middle; caudal hollow rattling quills less developed, the cylindrical portion measuring, in Indian skins, roughly 23 mm and less.

Subgenus ACANTHION Cuvier, 1822

There is one species in India, characterized by its relatively lengthened nasals.

Species 2. *HYSTRIX HODGSONI* Gray, 1847.

7. (8). Small race, occipitonasal length not exceeding 119.5 mm in adult; length of nasals at highest about 66 mm; caudal rattling quills on tail less well open.

3. *Hystrix hodgsoni hodgsoni* Gray, 1847. About half a dozen specimens examined, including co-types and type of *"alophus"* Hodgson, 1847, from the following localities; Hathibun in Nepal, Sikkim, no exact locality, and Longpa in the Naga Hills, Assam.

8. (7). Larger race, occipitonasal length not less than 125.3 mm in adult skulls with M^3 fully cut; length of nasal 66 mm at lowest, usually more; caudal rattling quills (in Indian skins) on tail more open and developed.

4. *Hystrix hodgsoni subcristata* Swinhoe, 1870. Synonyms, in my opinion, include *"klossi"* Thomas, 1916, and *"millsi"* Thomas, 1922. This race is typically from South China. About 8 specimens including types of *subcristata* and both synonyms listed, examined from Changsii, Okotso and Sangrachu, all in the Naga Hills, Assam, and from Bankason and Tenasserim Town in Tenasserim; also, some extralimital material.

9. (6). External covering at highest development, profuse growth of long bristles on head forming well developed crest; main quills of back very long and always with several alternating blackish and white rings; caudal hollow rattling quills highly developed, the cylindrical portion in some Indian specimens measuring about 60 mm or exceeding 50 mm.

Subgenus HYSTRIX Linnaeus, 1758

There is one species in India, characterized within the subgenus by its relatively short and narrow nasals.

Species 3. *HYSTRIX LEUCURA* Sykes, 1831.

This is the *Hystrix hirsutirostris* Brandt, 1835, and of Russian authors. Its synonyms include *"malabarica"* Sclater 1865, *"cuneiceps"* Wroughton, 1912, and most probably *"blanfordi"* Muller, 1911. On the material examined it does not seem possible to divide this porcupine into subspecies in a satisfactory manner, but skulls from Ceylon and from Nepal average smaller than those from other parts of India listed below.

5. *Hystrix leucura leucura* Sykes, 1831. About 30 specimens, including the type, and type of *"cuneiceps"*, examined from Nepal; Horai in Kumaon; Tochi Valley (Bonnu district), and Saharunpur, (Siwalik Hills), Punjab Ashkote, Kashmir; Khojdar, Baluchistan; Bijnor in United Provinces; Sambhar, Rajputana; Gambat, Mirwal, Mirpur, all in Sind; Nokania, Cutch; Sehore, Central India; Hoshangabad, Central Provinces; Dharwar; Nilgiri Hills; Shambalgamur, Palni Hills; Deccan; Cochin in Travancore; Gammaduwa, Mousekande, and St. George, (Matugama), in Ceylon.

The occipitonasal length of this species varies between about 127 and 161 mm and at extreme development it is the largest of Asiatic rodents, as judged by the length of the skull.

10. (1). Lower jaw with angular portion never distorted outwards by specialized limb of masseter lateralis superficialis; angular portion either slightly inflected (pulled inwards) or without peculiarity, except that occasionally be perforated. . . . (11)

11.(202). Infraorbital foramen not or scarcely open for muscle transmission; skull with well marked or traceable postorbital processes; jugal bone long; cheekteeth 5/4 or 4/4 in number, the extra upper premolar when present usually small, the other premolars little reduced in size; pattern of cheekteeth normally a series of transverse ridges and corner cusps in upper series; lower molars usually basin-shaped, with cusps at each corner; fibula not fused with tibia. Externally modified for arboreal or terrestrial life, sometimes with flying-membrane attached to sides; tail always fully haired.

FAMILY SCIURIDAE

12. (69). Flying membrane present, attached to sides of body. . . . (13)

13. (14). "Cheekteeth strongly hypsodont; inner borders of upper molars proximally subangulate, their upper surfaces flat"; fur excessively thick and heavy; sole heavily haired. A large species, hindfoot about 85 mm. (No skulls available to me for examination.)

Genus EUPETAURUS Thomas, 1888

There is only one species,

Species 4. *EUPETAURUS CINEREUS* Thomas, 1888.

6. *Eupetaurus cinereus cinereus* Thomas, 1888. A few skins, including a co-type, have been examined from Astor Valley, Chitral, and Gilgit in Kashmir.

14. (13). Cheekteeth not strongly hypsodont, their inner borders in upper series more rounded, their surfaces normally not flat; as a rule fur less thick and heavy, and sole not heavily haired. Except in certain forms of *Petaurista*, hindfoot less than 85 mm. . . . (15)

15. (50). Lower molars complex and excessively wrinkled, lacking large central depression characteristic of nearly all normal Sciuridae; in its place are numerous, small, partially or completely isolated depressions on crown surface, the general effect complex (normal sciurine pattern of lower molars thus masked); upper molars to a greater or lesser extent also wrinkled. . . . (16)

16. (47). Occipitonasal length in adult skull normally not less than 60 mm; width of frontals ("least interorbital width") generally more than one fifth of occipitonasal length; length of upper toothrow normally more than one fifth of occipitonasal length, and more than 13 mm (12.7 mm and more); M^3 normally has two transverse ridges between anterior and posterior margins of tooth, or elements corresponding to two main ridges, *i.e.*, second main ridge has not become obliterated.

Genus PETAURISTA Link, 1795

17. (26). Relatively small species, fully adult skull rarely reaching 65 mm in occipitonasal length. (This species occurs with *P. petaurista* throughout its range, and is always smaller than that species in any place where the two occur together.)
Species 5. *PETAURISTA ELEGANS* Temminck, 1839.
The typical race is from an Island south of Java.

18. (19). Large white spots on forepart of back.
7. *Petaurista elegans marica* Thomas, 1912. One Indian specimen examined from Namhsan (40 mi. E Mogok), in Shan States, Burma. The type, from Yunnan, has also been examined. This form is only doubtfully distinguishable from *P. e. punctatus* Gray, 1846, from Malacca.

19. (18). No large white spots on back. . . . (20)

20. (21). Occipitonasal length of type, and only known specimen less than 61 mm.
8. *Petaurista elegans sibylla* Thomas, 1916. The type skull examined, from 50 mi. W Kindat in Chin Hills, Burma. According to descriptions this form is correctly placed in this key, but I have not been able to re-examine the type skin.

21. (20). Occipitonasal length normally exceeds 61 mm. . . . (22)

22. (25). Back less brown; occipitonasal length does not exceed 64.1 mm in material examined. . . . (23)

23. (24). Length of nasals exceeds 19.3 mm.
9. *Petaurista elegans gorkhali* Lindsay, 1929. Three specimens, the type included, from Apoon Sottidanda, and Barpak (Gorkha), Nepal, 12,000 ft. were examined.

24. (23). Length of nasals 19.3 mm or less, in material examined.
10. *Petaurista elegans clarkei* Thomas, 1922. (From Yunnan. No Indian material has been examined, but this form is recorded from North Burma by Anthony, 1941. The type is in the British Museum.)

25. (22). Back usually browner; occipitonasal length in specimens available 64.7 mm or more.
11. *Petaurista elegans caniceps* Gray, 1842. Three specimens, including the type, and the type of "*senex*" Hodgson, 1844, examined. I feel some doubt about the allocation of the last name, as its type skull is a little too large for this species. Localities: Sikkim and Nepal, no exact localities.

26. (17). Relatively larger species; in Indian forms, length of occipitonasal in fully adult skulls more than 65 mm. . . . (27)

27. (28). Head, including forehead, white and strongly contrasted with back; general color red and white.

Species 6. *PETAURISTA ALBORUFUS*, Milne-Edwards, 1870.

The typical race is from Szechuan, China. I provisionally transfer to this species one of the Indian races because of the possibility that it may occur with some of the subspecies of *P. petaurista*. It is, on the whole, less specialized in color pattern than Chinese races.

12. *Petaurista alborufus candidulus* Wroughton, 1911. Synonym, "*taylori*" Thomas, 1914. About a dozen specimens, including the type of both names just listed, examined from: Okotso and no exact locality (5,000 ft.) in Naga Hills, Assam; Dilkoosha, Cachar; Bishampur, Manipur; Kindat and 6 mi. W Kindat, Kin, Lagan Reserve (Lower Chindwin), and Tatkon, west Burma. Mogaung, eastern Burma; near Bankason, Tenasserim.

28. (27). Head not white nor strongly contrasted with back (cheeks may be white, but with very rare individual exceptions, never forehead). . . . (29)

29. (30). Large dark saddlepatch on back present or suggested; middle of neck and back always markedly darker than sides and shoulders, and generally darker than parachute.

Species 7. *PETAURISTA MAGNIFICUS* Hodgson, 1836.

13. *Petaurista magnificus magnificus* Hodgson, 1836. Synonyms: "*nobilis*" Gray, 1842, and "*chrysotrix*" Hodgson, 1844. About eight specimens examined, including type skin, and type of "*nobilis*", from Darjiling, Sedonchen in Sikkim, Naivacot and Satthar Hill (Gorkha) in Nepal. This form is easily distinguished from other Indian forms in appearance, and I retain it as a species because of the possibility that it may occur with *P. petaurista albiventer*.

30. (29). No dark saddlepatch on back, and middle of neck and back not markedly darker than and contrasted with sides, shoulders, or parachute.

Species 8. *PETAURISTA PETAURISTA* Pallas, 1766.

The typical race is from Java. This is the first specific name in the genus, and to it I refer all the remainder in India, as races.

31. (42). Underparts white, or gray, or dull, never with any rufous tinge. . . . (32)

32. (35). Tail mostly black, and with long black terminal portion. . . . (33)

33. (34). Frontals proportionately wider, their combined width most often exceeding 18 mm in material examined.

14. *Petaurista petaurista lanka* Wroughton, 1911. About seven specimens, including the type examined, from Gammaduwa, Kandy, Kumbukkan, and Mousekande, all Ceylon.

34. (33). Frontals proportionately narrower, their combined width less than 18 mm and most often less than 17 mm.

15. *Petaurista petaurista philippensis* Elliot, 1839. Synonyms apparently include "*oral*" Tickell, 1842, and "*cinderella*" Wroughton, 1911. About 20 specimens, examined including co-types, and the type of "*cinderella*" from Luia, Chaibassa, Orissa; Pili, Sipna Valley, Berar; Pempri Dangs, and Waghai Dangs; Jog, Gersoppa, North Kanara; Haleri, Kutta, Srimangala and Virajpet, all Coorg; Kotagiri and Kodai-kanal, Nilgiri Hills; Shevaroy Hill, Eastern Ghats. South Mahratta; Karapara, Cochin; Trivandrum, Travancore. Tigershola, Palni Hills.

35. (32). Tail mostly gray, or only with short black terminal portion. . . . (36)

36. (37). Occipitonasal length of adult skull about 74.8 mm or more in material available; length of tail exceeds 500 mm in skins examined.

16. *Petaurista petaurista cineraceus* Blyth, 1847. A few specimens (less than 10) examined from 20, 30 and 40 mi. NW Toungoo, and 70 mi. N Pegu in Burma, and from Hankaryit and Wimpong, (Thaton), in Tenasserim.

37. (36). Occipitonasal length of adult skull does not exceed 70.8 mm in material examined; tail length in available skins does not reach 500 mm. . . . (38)

38. (39). Dorsal surface suffused with rufous.

17. *Petaurista petaurista primrosei* Thomas, 1926. The type examined, from Sullivan Island, Mergui Archipelago.

39. (38). Dorsal surface not as just described, but drab. . . . (40)

40. (41). Occipitonasal length of skull less than 67 mm in material examined.

18. *Petaurista petaurista mergulus* Thomas, 1922. Three specimens, the type included, from Ross Island and Tavoy Island, Mergui Archipelago, examined.

41. (40). Occipitonasal length of skull exceeds 70 mm in material examined.

19. *Petaurista petaurista reguli* Thomas, 1926. Two specimens, the type included, from King Island and Malcolm Island, Mergui Archipelago, examined.

42. (31). Underparts red or white but always with rufous tinge or some reddish or rufous markings apparent on some part of them. . . . (43)

43. (44). Largest of Indian *Petaurista*, occipitonasal length not less than 77 mm (in Indian specimen, 81 mm).

20. *Petaurista petaurista lylei* Bonhote, 1900. Typically from Siam. From material available, I do not think that the form *"venningi"* Thomas, 1914, can be separated from *lylei* with certainty. One Indian specimen, the type of *"venningi"*, from Kalaw, Shan States, Burma, and some extralimital material including the type of *lylei*, have been examined.

44. (43). Occipitonasal length does not exceed 76.3 mm in material available. . . . (45)

45. (46). Occipitonasal length about 76 mm; back mostly deep dark red.

21. *Petaurista petaurista yunanensis* Anderson, 1875. Typically from Momein, Yunnan. About half a dozen specimens, from Chaglon, Dreyi, and Tiki, all Mishmi, and from Adung Valley and Hpimaw, (Salween-Irrawaddy divide) in North Burma were examined.

46. (45). Occipitonasal length does not exceed 73.1 mm; red of back when present lighter, less deep and dark.

22. *Petaurista petaurista albiventer* Gray, 1834. I believe that there is only one form of *Petaurista* in North West India, and that the synonyms include *"inornatus"* Geoffroy, 1844, *"birrelli"* Wroughton, 1911, and *"fulvinus"* Wroughton, 1911. About 17 specimens have been examined, including types of all names just listed except *"inornatus"*, of which we possess several specimens, from the following localities: Naga Hills, Assam; Nepal; Garwhal and Naini Tal in Kumaon; Murree, Baragali (Murree Hills), and Thandiani (Murree), Kothi and Rahla, Lahul, and Simla, all Punjab; Doongla-gali, North West Frontier Province; Mianjani Hill, Hazara district; Islamabad, Khargeskote, Liddar Valley, Nasai, Pahlgahm, and Sardalla, all Kashmir.

47. (16). Occipitonasal length about 42 mm; width of frontals less than one-fifth of occipitonasal length; length of upper toothrow roughly 10 mm or less (upper and lower molars extremely complexly wrinkled).

Genus BELOMYS Thomas, 1908

There is one species.

Species 9. *BELOMYS PEARSONI* Gray, 1842.

48. (49). Upper toothrow in skulls available 9.6 mm or more in length, most often about 10 mm.

23. *Belomys pearsoni pearsoni* Gray, 1842. Very few specimens available, the type included, from Sikkim, Darjiling and the Naga Hills in Assam.

49. (48). Upper toothrow not exceeding 9 mm, usually less.

24. *Belomys pearsoni trichotis* Thomas, 1908. Very few specimens available, the type included, from the following localities: Machi in Manipur; 40 mi. W Kalewa and Yin, both Chindwin River, Burma. (The material in London for *Belomys* is not representative, and results obtained must be regarded as provisional.)

50. (15). Lower molars less excessively wrinkled, the large central depression characteristic of most Sciuridae present and clear in each tooth; upper molars have as a rule less tendency to wrinkling or complexity than in *Petaurista*, and much less than in *Belomys*; occipitonasal length rarely reaches 60 mm (only in four specimens out of about a hundred measured; all these are *Hylopetes fimbriatus*, and in this species the toothrow does not exceed 12.3 mm in length (compare with *Petaurista*) and is usually less than one-fifth of the occipitonasal length). In the remaining species of flying-squirrels, the toothrow does not exceed 12.3 mm. M^3 has one main transverse ridge between anterior and posterior margins of tooth. . . . (51)

51. (56). Bullae much flattened, scarcely rising above general level of base of skull.

Genus PETINOMYS Thomas, 1908

52. (53). Small species, occipitonasal length not exceeding 30.6 mm; hindfoot 21–24 mm.
Species 10. *PETINOMYS SETOSUS* Temminck, 1845.
The typical race is from Sumatra. Only one form reaches India, which is larger as a rule than the typical race.

25. *Petinomys setosus phipsoni* Thomas, 1916. Two specimens, the type included, from Tenasserim Village in Tenasserim examined.

53. (52). Much larger species, occipitonasal length not less than 55.5 mm; hindfoot about 52 mm.
Species 11. *PETINOMYS FUSCOCAPILLUS* Jerdon, 1847.

54. (55). Cheeks and sides of belly white.

26. *Petinomys fuscocapillus fuscocapillus* Jerdon, 1847. One skin from Travancore examined.

55. (54). Cheeks and belly gray.

27. *Petinomys fuscocapillus layardi* Kelaart, 1850. Three specimens, the type included, from Wellawaya and no exact locality in Ceylon examined. The material seen for forms 26 and 27 is far from representative, and the results are extremely provisional.

56. (51). Bullae not specially flattened, not abnormal.

Genus HYLOPETES Thomas, 1908

57. (60). Larger, occipitonasal length not less than 55.2 mm; nasals, proportionately longer, usually more than 17 mm in length; zygomatic plate rather more high and upstanding.

Subgenus EOGLAUCOMYS Howell, 1915

The differences between *Eoglaucomys* and *Hylopetes* seem more subgeneric than generic. There is only one species of *Eoglaucomys*.
Species 12. HYLOPETES FIMBRIATUS Gray, 1837.

58. (59). Larger, occipitonasal length (in one skull available, which is adult but not old, with parietal ridges separate and not approached to each other) 61.7 mm.

28. *Hylopetes fimbriatus baberi* Blyth, 1847. Typically from Afghanistan. Four or more specimens examined from Kagan Valley, Hazara, and Kashmir, no exact locality.

59. (58). Smaller, occipitonasal length (oldest skulls available, with parietal ridges approached to each other or fused) not more than 61.4 mm and with one exception not reaching 61 mm.

29. *Hylopetes fimbriatus fimbriatus* Gray, 1837. Roughly 20 specimens, the type included, examined from: Gilgit, Nasi, Sardalla, all Kashmir; Bhurban (Murree), Gharial, Murree, Naggar (Lahul), Pongye, (Chamba), Simla, Thandiani, Tuan (Pangi), all Punjab; near base of Diobani Mountain (locality not traced).

60. (57). Smaller, occipitonasal length not exceeding 52.8 mm; nasals, proportionately shorter, less than 16 mm in length; zygomatic plate low . . . . (61)

Subgenus HYLOPETES Thomas, 1908

61. (64). Larger, occipitonasal length at least 42.5 mm, but usually exceeds 45 mm; hindfoot 36 mm or more. . . . (62)

Species 13. HYLOPETES ALBONIGER, Hodgson, 1836.

62. (63). Occipitonasal length roughly 42.5 mm.

30. *Hylopetes alboniger leonardi* Thomas, 1921. The type from Kachin, 28.5N., 97.25E. in North Burma examined.

63. (62). Occipitonasal length not less than 45.2 mm.

31. *Hylopetes alboniger alboniger* Hodgson, 1836. Synonym, probably, *"orinus"* G. Allen, 1940, and *"turnbulli"* Gray, 1837. About 23 specimens, including the type of *"turnbulli"* and three co-types of *alboniger*, examined from Nepal, (Sipuri and no exact locality); Ambootia, Darjiling; Pashok, Sikkim; Bharnabhari, Bhutan Duars; Silhet; Khonshnong in Jaintia Hills, Mokokchung, and 5000 ft. in Naga Hills, Assam; Machi, Manipur; Dening, Mishmi; 30–50 mi. W Kindat in west Burma; Kachin, (28N., 97E.) in North Burma, also Nam Tamai Valley and Nam Tisang. Some extralimital material also examined.

64. (61). Smaller, occipitonasal length not exceeding 42 mm; hindfoot 34 mm and less . . . . (65)

65. (66). Bullae smaller, on average 20% of occipitonasal length at highest.

Species 14. *HYLOPETES SAGITTA* Linnaeus, 1766. The typical race is from Java. I include also the Sumatran form *H. s. platyurus* in this species, although Chasen, 1940, made it a distinct species, stating that it occurs with *H. spadiceus*. One race of *H. sagitta* reaches Indian territory.

32. *Hylopetes sagitta belone* Thomas, 1908. Four Indian specimens from Banlaw in Tenasserim examined. The type from Terutau Island is in the British Museum. It is smaller in size than the typical race.

66. (65). Bullae larger, on average at least 21% of occipitonasal length, usually more . . . . (67)

67. (68). Smaller, occipitonasal length not exceeding 33.5 mm; hindfoot 27 mm and less.

Species 15. *HYLOPETES SPADICEUS* Blyth, 1847.

33. *Hylopetes spadiceus spadiceus* Blyth, 1847. This is a valid or definable species, although Chasen, 1940, made it a race of *H. sagitta*, stating that it occurs with *H. platyurus* in the Malay States. Chasen retained *platyurus* as a species, but in London material it is not definable as a species compared with *H. sagitta* and its other races, whereas *H. spadiceus* can be retained, as just outlined. Two Indian specimens, including a co-type, and some extralimital material have been examined. Indian localities: Maymyo, Burma, and Arakan.

68. (67). Larger, occipitonasal length not less than 37.5 mm in material examined; hindfoot 29 mm and more.

Species 16. *HYLOPETES PHAYREI* Blyth, 1859.

34. *Hylopetes phayrei phayrei* Blyth, 1859. Synonyms, *"probus"* Thomas, 1914, and *"laotum"* Thomas, 1914. A dozen or more specimens, including the type of *"probus"* examined from the following localities: Pegu Yomas, and Mount Poppa in Burma; also a skin from Manipur, but its identification is not certain.

69. (12). No flying-membrane present. . . . (70)

70. (75). Occipitonasal length, in European and Asiatic forms, not less than 83.5 mm (may exceed 100 mm); braincase flattened; heavy sagittal crest present; orbit (measured from lachrimal to front of posterior zygomatic root just after this has left squamosal) long, clearly more than one-third of occipitonasal length

(this character also found in flying squirrels); P^3 large and functional; external form terrestrial, the middle finger of hand longest; tail short, rather less than half the length of head and body. . . . . (71)

Genus MARMOTA Frisch, 1775, (or Blumenbach, 1779)

71. (74). Tail approaching half the length of head and body (on average about 47% of the head and body length, as far as can be ascertained) or at least clearly more than one third of the head and body length . . . . (72)
Species 17. *MARMOTA CAUDATA* Jacquemont, 1844.

72. (73). Large dark saddlepatch present on back, noticeably contrasted with the sides, in both sexes.
35. *Marmota caudata caudata* Jacquemont, 1844. Seven or more specimens, from Kagan Valley, Hazara, (North West Frontier Province), Burzil Pass, Deosai (Baltistan), North of Tilel Valley, all Kashmir; Hills between Wardwan and Kashmir.

73. (72). No dark saddlepatch on back, at least in females.
36. *Marmota caudata aurea* Blanford, 1875. Typically from Chinese Turkestan. I have been unable to examine male skins of *aurea*. As synonyms I include "*littledalei*" Thomas, 1909, "*flavinus*" Thomas, 1909, and "*stirlingi*" Thomas, 1916. This seems to be the *Marmota caudata* of Russian authors, *?nec* Jacquemont. The type of "*stirlingi*," from Chitral (head of Chitral Nullah), is the only Indian specimen examined.

74. (71). Tail shorter, less than one-third of head and body length, as far as can be ascertained, or about a third of this length.
Species 18. *MARMOTA BOBAK* Muller, 1776. Typically from Poland. A species characterized by its short fur. One subspecies, which is unusually large in size, inhabits North India and China in part ("*robusta*," Milne-Edwards, 1870, is probably the same).
37. *Marmota bobak himalayana* Hodgson, 1841. Thirteen or more specimens, a type included, examined from Sikkim; Nepal; Lingti and Sissoo, Lahul; Hoti and Niti, Garwhal; Dakpo, Digr, Khardong, Sassar Pass, and Tyan (most of these localities appear to be in Ladak); and Skardu (Baltistan).

75. (70). Occipitonasal length not exceeding 81 mm; braincase usually less flattened, and sagittal crest most often absent, but when present light and weak; orbit as a rule less than one-third of occipitonasal length (or rarely approximates this percentage in some forms of *Ratufa*); P^4 usually reduced, or absent; external form arboreal; fourth finger of hand tends to be dominant; tail less shortened, more than half the head and body length (may be longer than the head and body); general form squirrel-like. . . . (76)

76.(101). Large squirrels, occipitonasal length exceeding 60 mm; frontals very wide, their least width sometimes as much as 40% of occipitonasal length; palate (measured from the front of the incisors to the back of the palate) very short; only four upper cheekteeth. . . . (77)

Genus RATUFA Gray, 1867

(In the external skin and color characters which are here given for this genus, *Funambulus*, *Callosciurus* and the remainder of Squirrels that follow, due attention has been paid to the possibility that characters may be based on seasonal changes. Most of the races retained have been based on skins collected in the four seasons of the year, but when a race is little known, and only known by a series of skins collected in one or two months of the year, then attention will be drawn to that fact.)

77. (82). Hindlimbs pale like underparts; rather small, occipitonasal length seldom more than 69 mm (reached 70 mm in only three skulls measured). . . . (78)
Species 19. *RATUFA MACROURA* Pennant, 1769.

78. (79). General color light and grizzled, grayish or brownish, not black.

38. *Ratufa macroura dandolena* Thomas and Wroughton, 1915. Synonym, apparently, *"sinhala"* Phillips, 1931. I am not able to distinguish this form with certainty in the material seen. About 20 specimens, including types of both names just listed, were examined from the following localities: Kombu in Nilgiri Hills, North slope of Palni Hills, Coimbatore, Chettiri Range, Kurumbapatti in Eastern Ghats, and foothills of Shrivilliputtur, all in southern India; Hambantota, near Kentalei, Kumbukkan, Maha-oya, Mankeni, Mousekande, Rama, Tirrapara, and Wellawaya, all in Ceylon.

79. (78). General color above black. . . . (80)

80. (81). Tail entirely black.

39. *Ratufa macroura melanochra* Thomas and Wroughton, 1915. A few specimens, the type included, examined from Anasigalla, (Matugama), Kottawa and Sinharaja Forest, all Ceylon. Only skins collected in January available.

81. (80). Tail hairs tipped with white.

40. *Ratufa macroura macroura* Pennant, 1769. Two specimens, from Pattipola, Ceylon, examined. Skins collected in March and August.

82. (77). Hindlegs dark, like back (feet may be pale). (In Indian races of *Ratufa bicolor*, the occipitonasal length is not less than 70 mm, and in *Ratufa indica*, the occipitonasal length in material examined is less than 69 mm in 2 specimens out of more than 40 measured). . . . (83)

83. (92). General color of body deep red, at least in part, and always with hairy red ears; forelegs pale; neckpatch white. . . . (84)

Species 20. *RATUFA INDICA* Erxleben, 1777.

84. (89). Dorsal surface of body red, the red not mixed with black. . . . (85)

85. (88). Tail red with white tip, not black. (Skins for the next two races were collected in the winter months). . . . (86)

86. (87). Unusually large race, occipitonasal length not less than 77 mm.

41. *Ratufa indica superans* Ryley, 1913. Four specimens, the type included, examined from Makut and Wotekolli in Coorg (the latter the type locality).

87. (86). Smaller, occipitonasal length does not reach 77 mm.

42. *Ratufa indica indica* Erxleben, 1777. Nine or more specimens, including co-types of *"elphinstonei"* Sykes, 1831, examined from Ghatmatha and Helwak, Satara; Samasgi, Dharwar; Devikop (about 26 mi. S Dharwar); Yellapur, North Kanara, all in Western India. In addition there are two whitish skins from Surat Dangs (Mahal Dangs) which formed the basis of Blanford's race *R. i. dealbata*, 1897. I do not accept this as a valid race because of the strong possibility that the name is based on albinistic specimens. The type has been examined.

88. (85). Tail, except at tip, black. (Skins of this race were collected in February and May.)

43. *Ratufa indica bengalensis* Blanford, 1897. About five specimens, the type included, examined from Barampaddy Forest, Mysore, and Kutta in Coorg.

89. (84). Dorsal surface of body with some clear black patches or portions mixed with the red. . . . (90)

90. (91) Only shoulders and rump black (as well as tail); occipitonasal length usually less than 75 mm.

44. *Ratufa indica centralis* Ryley, 1913. Sixteen or more specimens, examined from Luia and Sangajota (Chaibassa), Orissa; source of Nerbudda River; Bori and Dhain, Hoshangabad; Kodura, Balapalli Range, Cuddapah; Chamarajnagar, Mysore; Coonoor and Kotagiri, Nilgiri Hills; Gantha, Coimbatore.

91. (90). Most of back black; either sides only are red or black of shoulders and rump joined by mid-dorsal saddlepatch or line; occipitonasal length usually exceeds 75 mm.

45. *Ratufa indica maxima* Schreber, 1784. About ten specimens, examined from Kodai-kanal and Ootacamund in Nilgiri Hills; Anamaad Estate and Otracoolie Estate, Malabar; Kukhal Shola in Palni Hills; Kotengady Estate, Cochin; Poumudi and Trivandrum, Travancore. Skins for this race were collected in April and November.

92. (83). General color never deep red; forelegs normally not entirely pale; no white neckpatch. . . . (93)

Species 21. *RATUFA BICOLOR* Sparrmann, 1778. The typical race is from Java. There seems no reason why the Indian forms occurring from Nepal eastwards should not be regarded as subspecies of this larger Malayan species.

93. (96). Ear tufted, to a greater or lesser extent; normally no yellow bar across forearm. . . . (94)

94. (95). Tail not lighter in color at its extreme tip.

46. *Ratufa bicolor gigantea* MacClelland, 1839. Synonyms include "*macruroides*" Hodgson, 1849, and probably "*stigmosa*" Thomas, 1923, which seems to be based on an inconstant character. More than 20 specimens fro mIndia, including types of the three names listed above, examined from Nepal; Pashok, Sikkim; Matanga River, Kamrup; Lanting, Cachar; Naga Hills, (no exact locality, Lakhuri, and Mokokchung), and Duragiri in Garo Hills, Assam; Dening, Dreyi, and Tiki, all Mishmi; Gokteik (Shan States), Haingyan (Chindwin), Hkamti, (both sides of Chindwin River), Kachin Hills, NE and SW of Kindat, Katha (Irrawaddy River), Kamaing, (near Myitkyina), Madaya Forest (55 mi. N Mandalay), Moungkan and 100 mi. N Myitkyina, all Burma. Some extralimital material has also been examined.

95. (94). Tail typically lighter in color at its extreme end.

47. *Ratufa bicolor lutrina* Thomas and Wroughton, 1916. A doubtful race. Both summer and winter skins have been examined. In order to define it, this race should be restricted to the localities here listed. About nine specimens, the type included, examined from Kabaw Valley (20–35 mi. W Kindat), and Tatkon, in West Burma. The last is the type locality.

96. (93). Ear not tufted; yellow of inner side of forearm more extensive, extending across wrist or forearm as a bar. . . . (97)

97. (98). Head and shoulders much darker than posterior part of back, which is usually light grayish brown; tail lighter than in races below (only skins collected in June available).

48. *Ratufa bicolor felli* Thomas and Wroughton, 1916. About seven specimens, including the type, examined from Yin (Lower Chindwin), West Burma.

98. (97). Posterior part of back darker and typically not very different from head and shoulders; tail darker; general color above black or dark brown, or a mixture of both. . . . (99)

99.(100). Length of orbit proportionately shorter, 23.4 mm at highest in our specimens but usually less than 23 mm; tail averages less than 120% of head and body length in our specimens.

49. *Ratufa bicolor celaenopepla* Miller, 1913. Four specimens examined from King Island, Kisseraing Island, and Sullivan Island, Mergui Archipelago. Skins collected in January and March.

100. (99). Length of orbit averages proportionately longer, 23.3 mm at lowest in our material, but generally more than 24 mm; tail averages more than 120% of head and body length.

50. *Ratufa bicolor phaeopepla* Miller, 1913. Apparently "*marana*" Thomas and Wroughton, 1916, is a synonym. About eight specimens, including the type of "*marana*", have been examined from Mount Poppa and NW of Toungoo, Burma; Bankason, Maliwun, Thoungyeh, Thaget and Victoria Point in Tenasserim.

101. (76). Smaller, occipitonasal length not reaching 60 mm; characters indicated for last genus not combined here; five upper cheekteeth. . . . (102)

102.(105). Pattern of cheekteeth abnormal, becoming flatcrowned, with isolated folds present in adult; upper molars become more or less horseshoe shaped; lower molars tend to become transversely ridged, the central depression characteristic of normal genera reduced and appearing as a pit-like central re-entrant fold; rostrum elongated, nasal length exceeds least interorbital width; coronoid process of mandible reduced; back striped. . . . (103)

Genus MENETES Thomas, 1908

There is only one species.

Species 22. *MENETES BERDMOREI*, Blyth 1849.

103.(104). Mid-dorsal stripe and dark stripes on either side more prominent and clear; light stripes outside last named dark stripes tend to be more striking, and whole striping of animal about at maximum for species. (The skins were collected in September).

51. *Menetes berdmorei decoratus* Thomas, 1914. Eight specimens, from Mount Poppa in Burma, the type included, were examined.

104.(103). Mid-dorsal stripe normally obsolete or weak, and dark stripes on either side weaker and less developed; light stripes as a rule less striking; whole striping of animal weaker and less clear.

52. *Menetes berdmorei berdmorei* Blyth, 1849. About 10 Indian specimens, and some extralimital material examined from 36–70 mi. N Pegu and Martaban in South Burma; Bankason, Banlaw, Hankaryit, Mywadu, and Thaget in Tenasserim; Kisseraing Island, and Sullivan Island, Mergui Archipelago.

105.(102). Pattern of cheekteeth without extreme peculiarity. . . . (106)

106.(129). Coronoid process of mandible low and reduced; baculum simpler in structure ("lacking an accessory blade", Pocock); back striped; most often there is a tendency towards narrowing of frontal bones (except in *F. layardi*, a little known species in which, so far as ascertainable in the poor material available, the length of the nasals exceeds 11 mm.) . . . (107)

Genus FUNAMBULUS Lesson, 1835

107.(108). Color of underparts deep red; mid-dorsal stripe much brighter than outer pale ones; least interorbital measurement approximates or exceeds 13 mm; occipitonasal length less than 40 mm.

Species 23. *FUNAMBULUS LAYARDI* Blyth, 1849.

53. *Funambulus layardi layardi* Blyth, 1849. Including "*signatus*" Thomas, 1924. I place this form in synonymy because there is at least a strong possibility that its characters may be seasonal. It seems premature to separate this species into races on the very poor material available in London. It seems to be a rare species, and I have not seen the race named from the Western Ghats in South India, *dravidianus* Robinson, 1917, which is based on one immature specimen. Very few specimens have been examined, including the type of "*signatus*", from Mousekande, Rasagalla, Ratnapura, and south east of Ratnapura, in Ceylon. Skins collected in January and August. *F. layardi* apparently differs from the allied species in the genus chiefly by the fact that its frontals seem not be be narrowed, but I have no fully measurable skulls.

108.(107). Color of underparts not deep red; mid-dorsal stripe normally not much brighter than outer pale stripes; interorbital breadth in skulls of similar size to *F. layardi* less than 13 mm, and this measurement is reached only in large races of *F. tristriatus* in which occipitonasal length usually exceeds 43 mm. (Owing to the fragmentary nature of the skulls examined for *F. layardi*, it is not possible to give more exact distinguishing characters than those just indicated). . . . (109)

109.(112). Length of orbit normally less than 10 mm; color of underparts drab and dull; all stripes on back tend to be faint or indistinct; a small species, occipitonasal length not reaching 37 mm and usually less than 36 mm. . . . (110)

Species 24. *FUNAMBULUS SUBLINEATUS* Waterhouse, 1838.

110.(111). Median dark stripes narrower, and pale stripes of back closer together; tail often as long as head and body.

54. *Funambulus sublineatus sublineatus* Waterhouse, 1838. About 18 specimens examined, including a type skin, and the type of *"delesserti"* Gervais, 1841, from Kutta in Coorg; Benhope, Coonoor, Kodai-kanal, Kotagiri in Nilgiri Hills; Wynaad, Madras; Tigershola in Palni Hills; Shernelly, Cochin; Kuttyani, Poumudi, and Trivandrum in Travancore.

111.(110). Median dark stripes wider, and pale stripes placed farther apart; tail usually shorter than head and body.

55. *Funambulus sublineatus obscurus* Pelzeln and Kohl, 1886. Synonym, *"kathleenae"* Thomas and Wroughton, 1915. Six specimens examined, including type of *"kathleenae"*, from Kottawa, Pattipola, and West Haputale (Ohiya), in Ceylon. The skins were collected in February and April.

112.(109). Length of orbit exceeds 10 mm; color of underparts whitish or light; stripes of back clear, contrasted, and well marked. . . . (113)

113.(126). Occipitonasal length usually less than 40 mm (about 14 exceptions in 185 skulls); length of palate (measured from front of incisors to back of palate) normally less than half the occipitonasal length (about 9 exceptions in 185 skulls) and less than 20 mm. . . . (114)

114.(115). Back with five light stripes; underside of tail without red line running down center.

Species 25. *FUNAMBULUS PENNANTI* Wroughton, 1905. This species occurs with *F. palmarum* in some places. In my opinion it is not possible to divide this species into subspecies.

56. *Funambulus pennanti pennanti*, Wroughton, 1905. Synonyms, *"argentescens"* Wroughton, 1905, and *"lutescens"* Wroughton, 1916. About 150 specimens examined, including types of the three names just listed, from Cooch Behar and Haldibari, south of Sikkim; Banbasa, Naivacot, Tribeni, Nepal Terai; Dela, Dhakuri, Jerna (Ramnagar), and Pilihbit (Rohilkund), Kumaon; Ambala, Siwalik Hills, East Punjab; Ara, Choan, Kallar-kahar, Sodhi (all Salt Range), also Rawalpindi, and Multan, western Punjab; Kohat, Peshawar, North West Frontier; Gajar, Kelat, Mand and Turbat in Baluchistan; Bohara, Garo, Jacobabad, Kashmor, Mirpur, Naundero, Pano Aquil, and west of Sehwan, all Sind; Azadpur, near Delhi. Mount Abu, and Sambhar, Rajputana; Bhind, Chorepura, Ghatigaon, and Morar, Gwalior; Sehore, Central India; Bhuj, Charwar, and Nokania in Cutch; Deesa, Danta, and Lunwa (Palanpur), Gujerat; Dhrangadhra, Junagadh, Rajkot, Salda, Sasan, Satapur, Sihor, Talala, and Vankaneer, Kathiawar; Daltongunj, Bihar; Midnipur, Bengal; Jagodih, Hazaribagh; Dhain, Lohagpur, and Sakot, Hoshangabad; Chichpalli, Chanda, and Asirgarh, Ganoor, Hewra, all Nimar, Central Provinces; Pili (Sipna Valley), Berar; Bhodwad, Parola, and Shernduri, Khandesh; Bundla, Surat district; Nasik, Bombay City, Poona, Karad and Madha, Satara district; Dharwar district.

115.(114). Back usually with three light stripes; underside of tail with reddish or red line running down center for greater or lesser extent.

Species 26. *FUNAMBULUS PALMARUM* Linnaeus, 1766. The key to the subspecies below is based on cranial and external measurements owing to the conviction that because of individual variation it is quite impossible to divide this species into races based on color alone. . . . (116)

116.(117). Nasals longer, approximating or exceeding 30% of occipitonasal length in majority of specimens.

57. *Funambulus palmarum kelaarti* Layard, 1849. Synonyms, apparently, *"olympius"* Thomas and Wroughton, 1915, and *"favonicus"* Thomas and Wroughton, 1915. More than 60 specimens examined, including the types of *"olympius"* and *"favonicus"*, from Ceylon: Ambawela, Apure, Aripo, Hambantota, Kala-oya, Kandy, Kottawa, Mankeni, Peradeniya, Putlam, Rama, Udugama, Urugalla, and Wellawaya.

117.(116). Nasals shorter, on average not reaching 30% of occipitonasal length. . . . (118)

118.(119). Interorbital breadth approximating or exceeding 30% of occipitonasal length in majority of specimens.

58. *Funambulus palmarum brodiei* Blyth, 1849. Ten specimens examined, from Cheddikulam and Mannar in Ceylon.

119.(118). Interorbital breadth rarely reaching 30% of occipitonasal length. . . . (120)

120.(121). Length of upper toothrow rarely reaching 7 mm.

59. *Funambulus palmarum robertsoni* Wroughton, 1916. About a dozen specimens examined, the type included, from Dhain, Pachmarhi, and Rorighat, Hoshangabad; Asirgarh and Sival, Nimar; Kolkaz, Berar, all in the Central Provinces.

121.(120). Length of upper toothrow exceeds 7 mm. . . . (122)

122.(125). Tail on average shorter than head and body. . . . (123)

123.(124). Length of head and body rarely exceeds 156 mm (two exceptions in 26 skins).

60. *Funambulus palmarum matugamensis* Lindsay, 1926. Twenty-six specimens examined, including the type, from Anasigalla and St. George (Matugama, Western Province), Ceylon.

124.(123). Length of head and body rarely less than 156 mm (one exception in 16 skins).

61. *Funambulus palmarum bellaricus* Wroughton, 1916. Sixteen specimens examined, including the type, from Bundla, Surat district (identification not sure), Vijayanagar, Bellary, Dharwar, Gadag, Hawbshavi and Samaśgi, Dharwar district; Bangalore, Kolar, and Seringapatam, Mysore.

125.(122). Length of tail in majority of specimens longer than head and body.

62. *Funambulus palmarum palmarum* Linnaeus 1766. Synonyms apparently include *"comorinus"* Wroughton, 1905, *"bengalensis"* Wroughton, 1916, and *"gossei"* Wroughton and Davidson, 1919. At least 36 specimens examined, including types of *"comorinus"*, *"bengalensis"*, and *"gossei"*, from Gajhundi, Hazaribagh, and Jagodih, Bihar; Kodura, Balapalli Range; Shevaroy Hill; Kurumbapatti, Salem district; Adyan and Kilpauk, Madras; Gantla, and Trinchinopoly, Coimbatore district; Benhope, Kotagiri in Nilgiri Hills; Machur, Palni Hills; Kuttyani and Trivandrum, Travancore; Mahendragon, Nagercorl, Nellitore, and Perumal.

126.(113). Occipitonasal length normally exceeds 40 mm; length of palate 20 mm or more, and usually more than half the occipitonasal length. . . . (127)

Species 27. *FUNAMBULUS TRISTRIATUS* Waterhouse, 1837.

127.(128). Occipitonasal length not less than 44.7 mm; length of palate not less than 23.5 mm.

63. *Funambulus tristriatus wroughtoni* Ryley, 1913. About 10 specimens examined, including the type, from Makut, Srimangala, Virajpet and Wotekolli in Coorg; Shernelly, Cochin; Kotengady Estate, Travancore.

128.(127). Occipitonasal length not exceeding 44.4 mm; length of palate less than 23 mm.

64. *Funambulus tristriatus tristriatus* Waterhouse, 1837. Synonyms include *"numarius"* Wroughton, 1916, and *"thomasi"* Wroughton and Davidson, 1919. About 40 specimens examined, including types of the three names just listed, from Helwak, Satara; Khed, Ratnagiri; Khandalla, western Ghats; Dharwar

district; Devikop, Mahratta; Gersoppa, Potoli and Sirsi, Kanara; Thana, Bombay; Kardibetta Forest and Sagar, Mysore; Wynaad, Madras; Bonaccord, Kuttyani, Merchiston and Poumudi, Travancore.

129.(106). Coronoid process of mandible not reduced; baculum more complex, "with an accessory blade present", (Pocock, Thomas); back generally not striped, except in subgenus *Tamiops* of *Callosciurus*, which contains species in which the nasals do not reach 11 mm in length, and in which the frontals are relatively wider than in normal species of *Funambulus*, (all species except *F. layardi*). . . . (130)

130.(141). Skull narrow, length of nasals usually exceeds interorbital breadth, which is usually less than 30% of occipitonasal length; rostrum somewhat elongated; orbit normally less than 30% of occipitonasal length, and in Indian specimens less than 16 mm in length. . . . (131)

Genus DREMOMYS Heude, 1898

131.(134). Muzzle generally less elongated; orbit proportionately longer, averaging about 29% of occipitonasal length; underparts bright yellow; underside of tail and cheeks not red. . . . (132)

Species 28. *DREMOMYS LOKRIAH* Hodgson, 1836.

132.(133). Underparts usually brighter, washed with rich ochraceous.

65. *Dremomys lokriah lokriah* Hodgson, 1836. Synonyms, "*subflaviventris*" Gray, 1843, and "*bhotia*" Thomas, 1916. About 25 specimens examined, including types of the three names just listed, from Chandragiri Pass, Hathibun, and Satthar (Gorkha) in Nepal; Chuntang, Gangtok, Lachen, Ringin, Sedonchen, and Sukiapohkri, all in Sikkim or near Darjiling; Dreyi in Mishmi; Adung Valley, North Burma.

133.(132). Underparts duller, washed with buffy or yellowish.

66. *Dremomys lokriah macmillani* Thomas, 1916. Synonym, "*garonum*" Thomas, 1922. A dozen specimens examined, including types of both names just listed, from Rajapara in Kamrup, Duragiri and Tura in Garo Hills, Khonshnong in Jaintia Hills, Mokokchung in Naga Hills, and Naga Hills, 5000 ft., all Assam; Kabaw (50 mi. W Kindat) and Tatkon, West Burma.

134.(131). Muzzle more elongated; orbit proportionately shorter, on average 28% of occipitonasal length at highest, but most often less; in Indian forms, underparts not bright yellow. . . . (135)

135.(138). Underside of tail bright red through most of its length; in Indian races, cheeks red; toothrow generally proportionately longer. . . . (136)

Species 29. *DREMOMYS RUFIGENIS* Blanford, 1878.

136.(137). Occipitonasal length less than 53 mm.

67. *Dremomys rufigenis adamsoni* Thomas, 1914. Nine specimens examined, the type included, from Kindat (east side Chindwin River), Gokteik, Kalaw, Maymyo and Pyaung-gaung (in Shan States), Burma.

137.(136). Occipitonasal length normally exceeds 53 mm.

68. *Dremomys rufigenis rufigenis* Blanford, 1878. Synonym, "*opimus*" Thomas, 1916. At least seven Indian specimens examined, including types of both names just listed, from Mokokchung in Naga Hills, Assam; Hkamti in Burma; Mount Mooleyit, in Tenasserim; also, some extralimital material.

138.(135). Underside of tail and cheeks not red; toothrow generally proportionately shorter. . . . (139)

Species 30. *DREMOMYS PERNYI* Milne-Edwards, 1867.

139.(140). Large, occipitonasal length not less than 55.3 mm.

69. *Dremomys pernyi imus* Thomas, 1922. Three specimens examined, the type included, from Adung Valley and Mount Imaw Bum in North Burma.

140.(139). Smaller, occipitonasal length does not exceed 53.7 mm (in more than thirty specimens).

70. *Dremomys pernyi pernyi* Milne-Edwards, 1867. Typically from Szechuan China. Synonyms include *"mentosus"* Thomas, 1922, from Burma, and others from China. I have examined seven or more specimens from India, the type of *"mentosus"* included, and numerous extralimital specimens. Indian localities: 12 mi. SE Kohima, Mokokchung, and 5000 ft. (no exact locality) in Naga Hills, Assam; Manipur; 6 miles west of Kindat, west Burma.

141.(130). Skull wide, interorbital breadth usually exceeds nasal length and rarely as low as 30% of occipitonasal length. (In Indian forms, the sole exception among numerous races to the last statement seems to be *C. pygerythrus owensi*, which has the length of the orbit at least 16 mm). . . . (142)

Genus CALLOSCIURUS Gray, 1867

142.(147). Back prominently or clearly striped; small, occipitonasal length does not reach 38 mm.

Subgenus TAMIOPS Allen, 1906

143.(144). Larger on average, occipitonasal length very rarely less than 34 mm.

Species 31. *CALLOSCIURUS SWINHOEI* Milne-Edwards, 1874. This species occurs with the next in some places outside Indian territory.

71. *Callosciurus swinhoei maritimus* Bonhote, 1900. Typically from Fokien in China. Three Burmese specimens, taken in October and November, from the Adung Valley, North Burma, do not seem to me to differ from this race. In skull size in our material this race seems to be smaller in size than typical *swinhoei*, which is from Szechuan, China. There is in addition a form which might belong to this species, *C. s.? spencei* Thomas, 1921, from Kachin Province, North Burma. It might equally well be regarded as unidentifiable, as its skull is not known, and it was based on one skin only, in which the stripes of the back are weak, only the mid-dorsal clearly remaining. This may be a seasonal character. I have seen the types of both *maritimus* and *spencei*.

144.(143). Smaller on average, occipitonasal length very rarely reaches 34 mm. . . . (145)

Species 32. *CALLOSCIURUS MACLELLANDI* Horsfield, 1839.

145.(146). Mid-dorsal stripe darker than outer stripes; underparts not reddish or orange in color, nor with trace of these colors, and dull.

72. *Callosciurus maclellandi maclellandi* Horsfield, 1839. Synonyms include *"pembertoni"* Blyth 1842, and *"manipurensis"* Bonhote, 1900. About 50 specimens examined, including the types of the three names just listed, from Nepal; Chuntang, Darjiling district, Gangtok, Ringin and Sedonchen, all in or just south of Sikkim, Bhutan; Naga Hills (no locality and Mokokchung), in Assam; Diking, Cachar; Aimole, Loanghol, and Machi in Manipur; Sadiya; Dening, Dreyi, Ratana and Tiki, all in Mishmi; Hkamti, Haingyan, Homalin (Chindwin River), 50–65 mi. W Kindat, Kachin, near Krang, Myitkyina, Nam Nat Valley, Nam Tisang, Schwebo, and Tamanthe (Chindwin River), all Burma.

146.(145). Mid-dorsal stripe not darker than outer dark stripes, or scarcely so; underparts reddish or orange in color, or with clear traces of these colors, and bright.

73. *Callosciurus maclellandi barbei* Blyth, 1847. Synonym, *"kongensis"* Bonhote, 1901. More than 30 Indian specimens, and some extralimital material examined, including the type of *"kongensis"*. Indian localities: Hankaryit near Moulmein, 100 mi. S Moulmein, 30 mi. E Mandalay, Maymyo, Pyaunggaung (Shan States), 35 mi. SE Prome, east, north, and west of Toungoo, and Watau (Bhamo), all Burma; Amherst, Attaran River, Banlaw, Bankason, Kawkereik, Lampea, Lakya, Mywadu, Shan Mepale (Amherst district), Taok Plateau, Thoungyeh, near Tavoy, Tenasserim Town, and Ye, all Tenasserim; King Island and Kisseraing Island, Mergui Archipelago.

147.(142). Back without clear stripes, other than sometimes a mid-dorsal line; in Indian specimens, occipitonasal length not less than 42 mm. . . . (148)

Subgenus CALLOSCIURUS Gray, 1867

148.(161). Least interorbital breadth usually approximates a third of occipitonasal length, or less, and exceeds it only in relatively rare individual cases (all races have the majority of specimens with interorbital width as indicated); occipitonasal length usually less than 50 mm (in one race averages about 50 mm).

Species 33. *CALLOSCIURUS PYGERYTHRUS* Geoffroy, 1832.

149.(150). Larger, occipitonasal length apparently not under 50 mm; interorbital area proportionately narrower.

74. *Callosciurus pygerythrus owensi* Thomas and Wroughton, 1916. Three specimens examined, including the type, from Hkamti, Kauktaung and Minsin, all east side Chindwin River, Burma. The skins were collected in July.

150.(149). Smaller, occipitonasal length reaches 50 mm only in rare individual cases; interorbital area averages proportionately wider. . . . (151)

151.(152). Underparts dark gray, near blue-gray.

75. *Callosciurus pygerythrus stevensi* Thomas, 1908. About half a dozen specimens examined, including the type, from Beni Chang (Abor Miri Hills), Rotung (near Beni Chang), between Kalek and Mishang (Assam), Ledo in Naga Hills, Assam, Sadiya; south of Hukong Valley and 150 mi. N Myitkyina in Burma.

152.(151). Underparts paler. . . . (153)

153.(156). Normally with clear sharp contrasted black tailtip. . . . (154)

154.(155). Feet darker; underparts darker, reddish.

76. *Callosciurus pygerythrus pygerythrus* Geoffroy, 1832. Nine or more specimens, collected in January, February, March and May, from Pegu, 25–80 mi. N Pegu, Rangoon, Tamabin, and north, northwest, and west of Toungoo, all Burma, were examined.

155.(154). Feet paler; underparts paler, whitish.

77. *Callosciurus pygerythrus janetta* Thomas, 1914. About 29 specimens examined, including the type, collected between June and October, from Kauknaung, Mandalay, Monywa (east side Chindwin River), Mingun, Mount Poppa, Pyawbye, Schwebo district, and Yin (east side Chindwin River), all Burma.

156.(153). Black tail tip in majority of specimens absent or scarcely traceable. The remaining races of *C. pygerythrus* develop a seasonal thigh-patch. They are easily distinguished when this patch is present, but apparently cannot be separated from each other when it is absent). . . . (157)

157.(158). Thigh patch, when present, red; occipitonasal length in largest skulls reaches 50 mm.

78. *Callosciurus pygerythrus lokroides* Hodgson, 1836. About 36 specimens examined, including the type, and types of "*similis*" Gray, 1867, and "*assamensis*" Gray, 1843, from Aromari, Hetwada, Kuvapandy (Gorkha), Katmandu, Lahoripowa, Naivacot, and Sunachurn in Nepal; Dikchu, Gopaldhara, Mongpu Hills, Nimbong, Pashok, and Rongli in Sikkim or Darjiling district; Sivok in North Bengal; Bharnabhari and Hasimara, Bhutan Duars; Machi in Manipur.

158.(157). Thigh patch, when present, whitish, occipitonasal length in largest skulls does not reach 50 mm. . . . (159)

159.(160). Thigh patch, when present, white with an ochraceous patch or suffusion above it.

79. *Callosciurus pygerythrus bellona* Thomas and Wroughton, 1916. Ten specimens, the type included, collected in June, from Kin, (west side Chindwin River), Burma, examined.

160.(159). Thigh patch, when present, white or whitish but lacking the ochraceous patch.

80. *Callosciurus pygerythrus blythi* Tytler, 1854. I include as synonyms

"mearsi" Bonhote, 1906, and *"virgo"* Thomas and Wroughton, 1916. More than 40 specimens examined, including types of the three names just listed, from Angarakhata and Matanga River, Kamrup; Duragiri, Rangapari, and Tura in Garo Hills, Assam; Laitkynsao in Khasi Hills, Assam; Dilkoosha, Hatikhali and Lanka, Cachar; Naga Hills, 5000 ft. (no exact locality), Gologhat, Margherita, Mokokchung, Namdang and Sangrachu (all Naga Hills); Chinbyit, Kindat, and south and west of it, Setoo, west side Chindwin River, Homalin, Tamanthe, and Tatkon, all Chindwin River; Hkamti, Kabaw Valley and Mogaung, Burma.

161.(148). Least interorbital breadth, with few individual exceptions, clearly more than one-third of occipitonasal length (in all races the majority of specimens have interorbital width as just noted); in India, occipitonasal length usually exceeds 50 mm. . . . (162)

162.(163). Belly longitudinally banded black and white (a mid-ventral stripe bordered by two white patches, bordered by two lateral dark stripes).

Species 34. *CALLOSCIURUS QUINQUESTRIATUS* Anderson, 1871.

81. *Callosciurus quinquestriatus quinquestriatus* Anderson, 1871. Provisionally including *"imarius"* Thomas, 1926, which Anthony regarded as a valid race under the name *beebi* Allen, 1911. This species is not well known. Five or more specimens examined from Bhamo, Mount Imaw Bum, Sima (Myitkyina), Suikin (near Bhamo), and Teinzo, (north of Bhamo), all in northeast Burma.

163.(162). Belly not longtitudinally banded with black and white as described for the las species. . . . (164)

164.(173). Underparts dull, greenish gray like the back, or sometimes brown, but dull, and not strikingly colored; if red appears on underparts, it appears, normally, only as flankstripes outside a conspicuous greenish or brownish or dull mid-ventral area. (This species occurs extensively with *C. erythraeus*.)

Species 35. *CALLOSCIURUS CANICEPS* Gray, 1842.

165.(166). Smaller, occipitonasal length only rarely reaching 51 mm.

82. *Callosciurus caniceps shanicus* Ryley, 1914. About 10 specimens examined, including the type, from Gokteik, Hsipaw, Kalaw, Mongha, Maymyo and Pyaung-gaung in Burma, and Tavoy district, Tenasserim. (No mid-winter skins available.)

166.(165). Larger, occipitonasal length exceeds 52 mm. . . . (167)

167.(168). Back in winter pelage bright golden brown; summer skins lack flankpatches, and may also be distinguished by having the ventral parts almost always lighter than in *C. c. crumpi*, and having usually paler feet than in *C. c. davisoni* and immediate allies.

83. *Callosciurus caniceps caniceps* Gray, 1842. At least eight specimens examined from India; also, many extralimital specimens, the type of *"chrysonotus"* Blyth, 1847, and the type of *caniceps* included. Indian localities: Amherst, Hankaryit, Lampea, Moulmein, Shan Mepale (Amherst district), Tavoy and Thoungyeh in Tenasserim.

168.(167). Back never golden brown in color. Distinguished from *C. c. caniceps* (summer pelage) as indicated above. . . . (169)

169.(170). No flankpatches on sides; belly with dark reddy-brown tinge; nose reddish-brown.

84. *Callosciurus caniceps crumpi* Wroughton, 1916. Four specimens, the skins collected in November, and including the type, from Sedonchen in Sikkim examined. As far as can be seen with the material at present available, this form agrees specifically with *C. caniceps* and is provisionally transferred to this species.

170.(169). Reddish or brownish flankpatches each side of belly normally at least traceable; nose not reddish brown. . . . (171)

171.(172). Slightly smaller race, occipitonasal length most often less than 54 mm.

85. *Callosciurus caniceps sullivanus* Miller, 1903. Four specimens examined, from Malcolm Island and Sullivan Island, Mergui Archipelago.

172.(171). Slightly larger race, occipitonasal length exceeds 54 mm.

86. *Callosciurus caniceps davisoni* Bonhote, 1901. Synonyms appear to include "*tabaudius*" Thomas, 1922, and "*hastilis*" Thomas, 1923. Thirty-seven specimens including types of the three names just listed, examined from Bankason, Mergui district, Tenasserim Town and Victoria Point, all Tenasserim; Hastings Island, King Island, Kisseraing Island, and Tavoy Island, Mergui Archipelago; also, some extralimital material.

173.(164). Underparts bright, various in color, and most often red, but always bright rather than dull. . . . (174)

174.(175). Whole animal mainly red in color, back as well as belly; in Indian race, feet black or dark.

Species 36. *CALLOSCIURUS FERRUGINEUS* Cuvier, 1829.

Only one race occurs in India.

87. *Callosciurus ferrugineus ferrugineus* F. Cuvier, 1829. A dozen specimens examined from Dainguka (north of Pegu); Gokteik and Lawksawk (both in Shan States); Mount Poppa, Pegu Yomas, 20–70 mi. N Pegu, Rangoon, north, northwest and northeast of Toungoo, all in Burma; "*keraudrenii*" Lesson, 1830, is a synonym.

175.(174). Back normally not red or reddish in color, except in one color phase of *C. flavimanus rubex*, which when in its red phase differs from *C. ferrugineus* by having red feet. It may also be distinguished from those extralimital races of *C. ferrugineus* which antedate it, by average size of skull. The type of *C. flavimanus rubex* (not in red phase), is nearest *C. flavimanus* type, so I provisionally retain it in that species. It was named as a race of *C. sladeni* which I refer to *C. flavimanus*, the earlier name, as a subspecies. *C. ferrugineus* and *C. flavimanus* are here retained and defined as species because in some places they occur together. . . . (176)

176.(189). Hands and feet white or red or sandy-yellow, in contrast to limbs. . . . (177)

Species 37. *CALLOSCIURUS FLAVIMANUS* Geoffroy, 1832.

The typical race is from Annam. In size of skull it is about as in *C. f. rubex*, below, from which it differs by lack of red coloring in tail.

177.(180). Tip of tail clear black. . . . (178)

178.(179). Occipitonasal length usually exceeds 54 mm; clear dark flankpatches usually present on each side.

88. *Callosciurus flavimanus phayrei* Blyth, 1855. About 17 specimens, two co-types included, examined from Gokteik, Hsipaw, Pyaung-gaung and Se-en, all in Shan States; also east, north and northeast of Toungoo, Burma; Pahpoor and Wimpong (Thaton), in Tenasserim.

179.(178). Occipitonasal length usually less than 54 mm; dark flankstripes usually absent or obsolete (skins collected in July, August, and September).

89. *Callosciurus flavimanus blanfordi* Blyth, 1862. I think it is possible that this form may be a synonym of *C. f. phayrei*. Half a dozen specimens, the type included, examined from Nyapinium (east bank Irrawaddy River), Burma. Also one skin (not very typical) from Madaya Forest (40 mi. NE Mandalay), Burma.

180.(177). No black tailtip. . . . (181)

181.(182). Occipitonasal length about 54 mm at largest.

90. *Callosciurus flavimanus rubex* Thomas, 1914. This form occurs in two color phases, as noted above. At the same locality and in the same month individuals may be either red or brown dorsally. Eight specimens, the type included, examined from Yin, Chindwin River, Burma, and one specimen from Youngbintha, left bank of Irrawaddy River. Skins were collected in June

and October. (In the remaining subspecies, nearly all the skins available were taken in mid-summer. Only for *sladeni* have we also some material taken in November.)

182.(181). Occipitonasal length approximates or exceeds 55 mm, with 4 exceptions in 40 skulls. . . . (183)

183.(186). Underside of tail mostly white, or with a long whitish tuft. . . . (184)

184.(185). Back nearly white.

91. *Callosciurus flavimanus haringtoni* Thomas, 1905. Synonym; *"solutus"* Thomas, 1914, and most probably *"careyi"* Thomas and Wroughton, 1916. About 17 specimens, including types of the three names just listed, examined from Tamanthe, (65 mi. S Hkamti); Moungkan (20 mi. S), and Homalin, (20 mi. S), all east side of Chindwin River, Burma.

185.(184). Back much darker, grizzled dark gray.

92. *Callosciurus flavimanus millardi* Thomas and Wroughton, 1916. Three specimens, including the type examined, from Pyaungbyin (140 mi. S Hkamti), and 100 mi. N Kindat, east side Chindwin River, Burma.

186.(183). Underside of tail not white as a rule. . . . (187)

187.(188). Back paler, more brown; face less reddish in majority of specimens.

93. *Callosciurus flavimanus shortridgei* Thomas and Wroughton, 1916. Synonym, apparently, *"fryanus"* Thomas and Wroughton, 1916. About 17 specimens, including the types of both names just listed, examined from Hkamti, (26.5N., 95.55E.), Kauktaung, (25 mi. S), and Minsin, (25 mi. S), east side Chindwin River, Burma.

188.(187). Back darker, more gray; face conspicuously reddish.

94. *Callosciurus flavimanus sladeni* Anderson, 1871. Synonyms, *"bartoni"* Thomas, 1914, *"kemmisi"* Wroughton, 1908, and *"midas"* Thomas, 1914. Eighteen specimens, including the types of *"kemmisi"*, *"midas"* and *"bartoni"*, examined from Kindat, (180 mi. S Hkamti), east side Chindwin River, and 20 mi. SE Kindat; Katha, Myitkyina, and Schwebo, (Irrawaddy River district), and Uyu River, (50 mi. E Homalin), all Burma.

189.(176). Hands and feet normally dark, or nor contrasted with limbs (or not much paler than limbs); or if, as occasionally in *C. e. atrodorsalis*, feet paler than limbs, then this form may be distinguished by black mid-dorsal stripe or patch, which does not occur in races of *C. flavimanus* dealt with above.

Species 38. *CALLOSCIURUS ERYTHRAEUS* Pallas, 1778.

190.(191). Back normally with clear black mid-dorsal patch or stripe.

95. *Callosciurus erythraeus atrodorsalis* Gray, 1842. A dozen or more Indian specimens, many more from Siam, and two co-types have been examined. This form is difficult to classify, as its color characters seem excessively variable individually. Indian localities include Attaran River, Hankaryit, Lampea, 100 mi. S of Moulmein, Mywadu River, Maitho (Thoungyeen River), Shan Mepale (Amherst district), Taok Plateau and Thoungyeh, all Tenasserim.

191.(190). Back normally without a clear black mid-dorsal patch or stripe. . . . (192)

192.(193). Tail mostly red, or with a long red terminal tuft, with or without a white tip.

96. *Callosciurus erythraeus erythraeus* Pallas, 1778. I regard *"wellsi"* Wroughton, 1921, as a synonym. About 16 specimens, including the type of *"wellsi"*, examined from Kulsi and Rajapara, Kamrup; Duragiri and Tura in Garo Hills, Khasi Hills, and Khonshnong and Shangpung in Jaintia Hills, all Assam.

193.(192). Tail not red. . . . (194)

194.(195). Tail mainly white, but with clear black tip.

97. *Callosciurus erythraeus kinneari* Thomas and Wroughton, 1916. Seven specimens, including the type examined, from 40 mi. W Kindat, Nanthalet, and Tatkon, all Burma.

195.(194). Tail normally not as just described. . . . (196)

196.(197). Smaller, occipitonasal length seldom more than 51 mm, not reaching 52 mm in Indian material examined.

98. *Callosciurus erythraeus gordoni* Anderson, 1871. Three Indian skulls, a few unmeasured skins, and some extralimital material examined from Aini, Mishmi; Watau, Bhamo. A skin from Sadiya is perhaps misidentified.

197.(196). Larger, occipitonasal length normally exceeds 52 mm. . . . (198)

198.(199). Tail with long black terminal tuft, or sometimes wholly black.

99. *Callosciurus erythraeus erythrogaster* Blyth, 1842. Synonym, "*nagarum*" Thomas and Wroughton, 1916, and perhaps "*punctatissimus*" Gray, 1867, which is a little known form, not easy to allocate on material available. About 20 specimens examined, including types of "*punctatissimus*" and "*nagarum*", from Dilkoosha, Cachar ("*punctatissimus*"); Lanka, Cachar; Naga Hills, 5000 ft. (no exact locality), also 20 miles east of Kaluna, Mokokchung, and Powai (all Naga Hills), Syndai in Jaintia Hills, and Mikir Hills, all Assam; Aimole and Nooribazar in Manipur; Sadiya; Haingyan, Kindat, 50–65 mi. W Kindat, and Tamanthe, western Burma. Also some extralimital Indochinese material.

199.(198). Tail usually not conspicuously black terminally. (Except occasionally in *C. e. crotalius*). . . . (200)

200.(201). Tail averages darker, with some clear black coloring, and usually edged or tipped with white hairs; tip sometimes white.

100. *Callosciurus erythraeus crotalius* Thomas and Wroughton, 1916. Nine specimens examined, including the type, from Hkamti and south of Hukong Valley, Burma. Only summer skins available. This form seems very close to *C. e. castaneoventris* Gray, from Hainan, one of the earliest names in the species, but the skulls seem to average larger in the Burmese form.

201.(200). Tail averages paler, with very little or no black.

101. *Callosciurus erythraeus intermedius* Anderson, 1879. It seems probable that this name will have to stand for a race which has also been called "*bonhotei*" Robinson and Wroughton, 1911, from Szechuan, and "*aquilo*" Wroughton, 1921, from Dibong River, Sadiya, North Assam, and which is definable in British Museum material. Robinson and Kloss, 1918, gave the type locality for *intermedius* as the Dikrang Valley in Assam. About 18 Indian specimens examined, including the type of "*aquilo*", from Dibong River, Sadiya; Dening, Dreyi, Lohit Valley and Tiki, all Mishmi; East Hkamti Plain, Kachin and Nam Tamai in North Burma.

In addition to the large amount of material examined for the seven races of this species dealt with above, I have seen three skins representing two more named races, both of which differ from those above in having a reddish-brown forehead. These are *C. e. rubeculus* Miller, 1903, one specimen from Sungei Balik in Tenasserim, which in all probability is the same as the much earlier described *C. e. hyperythrus* Blyth, 1855; and *C. e. bhutanensis* Bonhote, 1901, two specimens, including the type, from Bhutan. The skull of the last race is not fully known. On this very inadequate material I am unable to include these two supposed forms in the key. Our *bhutanensis* skins have a darker tail than our *rubeculus* skin, and the latter specimen has a small skull, as in *C. e. gordoni*.

202. (11). Infraorbital foramen clearly open for muscle transmission. . . . (203)

203.(206). Zygomatic plate narrow, and completely beneath much enlarged infraorbital foramen; fibula reduced and fully fused with tibia; mandible with angular portion tending to be weak, and often perforated; cheekteeth complex, rooted, more or less cuspidate in Indian genera, and number 4/3 or 3/3 (extra upper premolar, which is present in Indian genera, small); jugal bone long.

FAMILY DIPODIDAE

204.(205). Three central metatarsal bones not fused to form a cannon-bone; bullae and mastoids small, not inflated; zygoma simple, with jugal slanting gradually up-

wards towards lachrimal; external form not modified for bipedal saltatorial life; five functional toes on hindfoot; frontal bones moderately constricted.

SUBFAMILY SICISTINAE

There is only one genus, which contains long-tailed mouse-like animals of very small size; occipitonasal length in Indian specimens about 20 mm in length.

Genus SICISTA Gray, 1827

One species occurs in Indian territory.

Species 39. *SICISTA CONCOLOR* Buchner, 1892.

Typical race from Kansu in China; one race inhabits India which differs from typical race in longer tail and also perhaps in shorter palate, but there is little material available for either. I have not been able to examine *S. c. flavus* True, 1894, from Central Kashmir.

102. *Sicista concolor leathemi* Thomas, 1893. About five specimens examined, including the type, from Kagan Valley, Hazara. Kagnarg Mountains, (Malangan), Rupal, Astor, and Krishnye Valley, Wardwan, all Kashmir.

205.(204). Three central metatarsal bones fused to form cannon-bone; bullae may or may not be strongly enlarged (not so in Indian species); zygoma in two sharply contrasted portions (horizontal and vertical) frontal bones scarcely constricted, their narrowest part immediately behind anterior zygomatic root; external form modified for bipedal saltatorial life; five or three hindtoes as a rule, but only three functional (outer ones when present do not reach ground).

SUBFAMILY DIPODINAE

Only one genus of this Palaearctic subfamily occurs in India.

Genus ALLACTAGA Cuvier, 1836

One species just reaches Indian territory. It is the smallest species of the genus; the occipitonasal length not exceeding 28.3 mm in our material.

Species 40. *ALLACTAGA ELATER* Lichtenstein, 1825. The Indian race may be separated as

103. *Allactaga elater indica* Gray, 1842. Upper toothrow longer than in specimens of typical race (available to me) from Russian Turkestan. I have measured a good series for both races. One Indian specimen examined from Sourab, Baluchistan. The type is in London, and I have examined many extralimital specimens. The type locality is in Afghanistan.

206.(203). Zygomatic plate broadened and tilted upwards to a greater or lesser degree; masseter lateralis muscle extending its line of attachment on to zygomatic plate; infraorbital foramen, usually narrower below than above, not so strongly enlarged as in last family; fibula fused with tibia; hindfoot with five functional toes; frontals generally somewhat narrowed; external form generally less specialized than in those families dealt with above, excepting Sicistinae, and those forms modified to subterranean life. . . . (207)

207.(210). Pattern of cheekteeth with many narrow transverse cross-ridges extending across each crown; in primitive forms, teeth more or less basin-shaped, with corner cusps, reminiscent of Sciuridae; in progressive forms, cheekteeth flat-crowned; angular portion of lower jaw usually with signs of inflection, and sometimes perforated; caecum usually absent; tail usually fully haired and bushy; palate proportionately short. (Simpson, 1945, prefers to call this family the Gliridae.)

FAMILY MUSCARDINIDAE

208.(209). Cheekteeth 4/4, premolars retained; bullae large and well inflated, their length in Indian skulls 8.4 mm; palate less imperfectly ossified; frontals proportionately narrower (in one Indian skull, 3.7 mm). (In the genus inhabiting India, the cheekteeth are cuspidate, basin shaped, and not flatcrowned).

SUBFAMILY MUSCARDININAE

One genus just reaches Indian territory.

Genus DRYOMYS Thomas, 1906

(For use of this name instead of the more familiar *Dyromys* Thomas, 1907, see Simpson, 1945, p. 92.)

There is one species.

Species 41. *DRYOMYS NITEDULA* Pallas, 1778. Typically from southern Russia. The Indian race may be distinguished from the typical race by its generally larger ear.

104. *Dryomys nitedula picta* Blanford, 1875. Two Indian specimens examined from Kurram Valley, North West Frontier; also, some extralimital material, including the type from Persia.

209.(208). Cheekteeth 3/3, premolars absent; bullae small, reduced, (less than 4.5 mm in length); palate rather poorly ossified, usually with a large pair of foramina between toothrows; frontals proportionately wider (in the Indian genus, their combined width exceeds 6 mm); cheekteeth flatcrowned, with depressions (between the ridges) tending to become isolated with wear on crown surface.

SUBFAMILY PLATACANTHOMYINAE

There is one genus in India.

Genus PLATACANTHOMYS Blyth, 1859

Only one species in India.

Species 42. *PLATACANTHOMYS LASIURUS* Blyth, 1859.

105. *Platacanthomys lasiurus lasiurus* Blyth, 1859. In addition to those already given, distinguishing characters of the genus *Platacanthomys* are: spiny fur, clawless hallux, bushy tail, well ridged skull, and occipitonasal length exceeding 30 mm. About 17 specimens examined, including a co-type, from Virajpet, Coorg; Mysore-Kanara border, (Neria, Cardamon Jungles, near Charmadi); Bonaccord, and Eva Gardens, Travancore.

210.(207). Pattern of cheekteeth various, but never like that described above for Muscardinidae; cheekteeth 3/3 in Asiatic genera; angular portion of mandible not perforated; caecum present, so far as known; jugal generally shortened and reduced; tail most often naked, and only rarely bushy. . . . (211)

211.(222). Infraorbital foramen reduced, its lower border nearly straight; zygomatic plate tilted very strongly upwards; masseter muscle extends its line of attachment on inside of infraorbital foramen, so far as known; cheekteeth flatcrowned, with inner and outer folds which ultimately isolate as islands on crown surface; cranially and to a certain extent externally specialized for fossorial life; mandible with lower incisor root forming a prominent knob below or near condylar process. . . . (212)

FAMILY RHIZOMYIDAE

212.(217). Incisors extremely pro-odont, best indicated in cranial measurements by fact that diastema usually approaches or exceeds 40% of occipitonasal length, and on average 39% of occipitonasal at lowest; M^1 is larger than M^2, and not worn below its level; condylobasal length (which in this family exceeds the occipitonasal length) less than 55 mm; occipitonasal length not more than 48 mm.

Genus CANNOMYS Thomas, 1915

There is one species.

Species 43. *CANNOMYS BADIUS* Hodgson, 1842.

213.(214). Upper toothrow not exceeding 9.2 mm in length; head and body length most often less than 200 mm; occipitonasal length most often less than 40 mm.

106. *Cannomys badius castaneus* Blyth, 1843. Synonym, probably, *"plumbescens"* Thomas, 1915. About a dozen specimens examined, the type of *"plumbescens"* included, from Gokteik, Maymyo, Pyaung-gaung, Qwetha, and Se-en in Shan States, 25–36 mi. N Toungoo, all Burma; Kokarest, and Wimpong (Thaton), in Tenasserim.

214.(213). Upper toothrow not less than 9.4 mm in length; head and body most often more than 200 mm in length; occipitonasal length exceeds 40 mm. . . . (215)

215.(216). Height of occiput (measured from top of foramen magnum to top of lambdoid crest) usually 10.8 mm and more; least interorbital breadth, 8.5 mm or less; fur tending to be shorter and harsher, and color tending to be slightly lighter.

107. *Cannomys badius pater* Thomas, 1915. Four specimens, including the type, examined from Mount Poppa, Burma.

216.(215). Height of occiput does not reach 10.8 mm (with one exception in 44 skulls); least interorbital breadth 8.7 mm and more; fur tending to be less short or harsh, and color tending to be slightly darker.

108. *Cannomys badius badius* Hodgson, 1842. More than 50 specimens, the type included, examined from Nepal, Sunachurn and no exact locality; Narbong, Darjiling; Hasimara, Bhutan Duars; Rajapara, Kamrup; Khasi Hills, Hot Springs and Khonshnong in Jaintia Hills, Gologhat and no exact locality in Naga Hills, Mikir Hills, all in Assam; Bishampur and Nooribazar in Manipur; Kabaw Valley, Kaduchang in Chin Hills, 20 mi. SW Kindat, and 50–65 mi. W Kindat, in Burma.

217.(212). Incisors less extremely pro-odont; diastema normally less than 40% (on average about 36%) of occipitonasal length; M^1 often smaller than M^2, and often worn below its level; condylobasal length not less than 57 mm; occipitonasal length not less than 55.5 mm. . . . (218)

Genus RHIZOMYS Gray, 1831

218.(219). Incisors more pro-odont, diastema approximating 36% of occipitonasal length (sometimes slightly more individually); M^1 scarcely smaller than M^2; toothrow shorter, clearly less than one-fifth of occipitonasal length.

Subgenus NYCTOCLEPTES Temminck, 1832

There is one species.

Species 44. *RHIZOMYS SUMATRENSIS* Raffles, 1822. Typically from Malacca. There is one subspecies inhabiting India.

109. *Rhizomys sumatrensis cinereus* MacClelland, 1842. Red on cheeks of adult more clearly marked than in typical race, also possibly averaging slightly larger than typical *sumatrensis*. Eleven Indian specimens examined from Maymyo, Mamsam Falls, Pyaung-gaung and Se-en in Burma; Ataran (50 mi. S Moulmein), Banlaw, Mergui, Thaget, and Tenasserim Town in Tenasserim; also some extralimital material.

219.(218). Incisors less pro-odont, diastema usually less than one third of occipitonasal length, or at most approximating 34% of it; M^1 normally smaller than M^2 in adult; toothrow exceeds one-fifth of occipitonasal length.

Subgenus RHIZOMYS Gray, 1831

220.(221). Height of occiput (measured from top of foramen magnum to top of lambdoid crest) always more than one quarter of occipitonasal length; fur very thick; general color effect greyish or grey.

Species 45. *RHIZOMYS SINENSIS* Gray, 1831. The typical race is from South China. One race, much larger than typical *sinensis*, inhabits North Burma.

110. *Rhizomys sinensis wardi* Thomas, 1921. Four specimens, including the type, examined from Mount Imaw Bum, Pass east of Lanpinghsien (26.27N. 98.28E.), and west of Maikla-Salween divide (26N., 98E.) in northeastern Burma. This form is perhaps a synonym of *R. s. vestitus* Milne-Edwards, 1871, from Szechuan. It averages slightly larger. In our material it cannot be distinguished from it with certainty in color.

221.(220). Height of occiput normally less than one quarter of occipitonasal length, and only exceeds this length in old or aberrant individuals; general color effect of body typically dark, almost chocolate brown, with many white-tipped hairs intermixed (fur short in lighter colored extralimital subspecies).

Species 46. *RHIZOMYS PRUINOSUS* Blyth, 1851.

111. *Rhizomys pruinosus pruinosus* Blyth, 1851. Synonym, "*senex*" Thomas, 1915. Ten specimens from India, and considerable extralimital material, including the type of "*senex*" from Yunnan, examined. Indian localities: Cherrapunji in Khasi Hills; Mokokchung, and no exact locality in the Naga Hills, Assam; Bishampur, and between Mongsench and Chantongia in Manipur; mountains east of Bhamo in East Burma.

222.(211). Infraorbital foramen (as a rule) less reduced, its lower border usually V-shaped; masseter muscle not, as far as known, extending its line of attachment on to inner side of infraorbital foramen; never combining the characters described for the last family. . . . (223)

FAMILY MURIDAE

Many authors prefer to divide this family into two families, Cricetidae and Muridae. The latter would contain the Murinae of this work; the former would contain, as subfamilies, the Cricetinae, Microtinae, and Gerbillinae of this work.

223.(258). Cheekteeth complexly prismatic in pattern, and frequently evergrowing; skull considerably specialized by general shifting forwards of ridges for jawmuscle attachment; supraorbital ridges when they fuse do so in interorbital region (rather than on parietals as in other rodents); squamosal crests developed; bullae enlarged; tail as a rule relatively short and hairy.

SUBFAMILY MICROTINAE

224.(225). M.3/3 reduced in size; cheekteeth rooted in adult; cranially extremely modified for subterranean life; incisors excessively pro-odont and enlarged; root of lower incisor forming prominent process outside condylar process of lower jaw; infraorbital foramen not narrow, lacking external plate or covering; tail usually shorter than hindfoot. (In Indian species, ridges of skull fuse to form a sagittal ridge which extends backwards over parietals to lambdoid crest; posterior palate specialized in the manner described below for *Microtus* and *Pitymys*.)

Genus ELLOBIUS Fischer, 1814

Only one species occurs in India.

Species 47. *ELLOBIUS FUSCOCAPILLUS* Blyth, 1841.

112. *Ellobius fuscocapillus fuscocapillus* Blyth, 1841. One Indian specimen examined from Mach (near Quetta) in Baluchistan; also, some extralimital material.

225.(224). M.3/3 not reduced in size; cheekteeth rootless in adult; skull without abnormal modifications as described above, and incisors less enlarged; when ridges of skull fuse, they do so in interorbital region, and never form a ridge extending backwards over parietals; infraorbital foramen narrow. . . . (226)

226.(247). Posterior palate terminates as a simple transverse shelf. . . . (227)

227.(232). Supraorbital ridges fuse to form median interorbital crest; palate proportionately longer, approximating or exceeding 60% of occipitonasal length; external form fossorial; cheekteeth with long-drawn-out appearance. . . . (228)

Genus HYPERACRIUS Miller, 1896

228.(229). Larger; occipitonasal length not less than 25.4 mm; upper toothrow not less than 6.2 mm in material available.

Species 48. *HYPERACRIUS WYNNEI* Blanford, 1880.

113. *Hyperacrius wynnei wynnei* Blanford, 1880. About 35 specimens (but only five skulls), two cotypes included, examined from Doongla-gali, North West Frontier; Sardalla, Kashmir; Gharial and Murree, Punjab. Kashmir skins are smaller in size apparently than Punjab specimens.

229.(228). Smaller; occipitonasal length not exceeding 24 mm; toothrow 6.0 mm or less, usually less, in material available (one exception). . . . (230)

Species 49. *HYPERACRIUS FERTILIS* True, 1894.

230.(231). Ear most often more than one-tenth of head and body length.

114. *Hyperacrius fertilis fertilis* True, 1894. About 16 specimens examined from Kagan Valley, Hazara; Bogarmana Glen; Dangail (Kishtwar); Gugga Nullah; Pyas (Kishtwar); Rattoo (Gilgit), and Tullian, all Kashmir.

231.(230). Ear most often less than one-tenth of head and body length.

115. *Hyperacrius fertilis brachelix* Miller, 1899. More than 10 specimens examined from Astormang, Aru Ravine, Chelum Valley, Dodri Pass, Dubian, Dachgam, Leddar Valley, Leyseh, Pahlgahm, Preslang Ravine, Rupal, Surez, Visirhim, Wardwan Valley, and Zogi-la Pass, all apparently in Kashmir. In the present state of our knowledge it does not seem possible to identify with certainty the animal described as *Hyperacrius aitchisoni* Miller, 1897, from Gulmerg, Kashmir. The type skull, which is in London, is in fragments, and it cannot be stated as yet whether this name is based on a race of *H. fertilis* or of *H. wynnei*.

232.(227). Supraorbital ridges remain separate in adult; palate proportionately shorter (in Indian forms averaging below 55% of occipitonasal length); external form not specially fossorial. . . . (233)

233.(244). Cheekteeth with relatively wide folds, and long-drawn-out appearance.

Genus ALTICOLA Blanford, 1881

234.(235). M^3 reduced, with very short heel and only two clear inner salient angles (one or at most two folds); tail very short, usually less than a quarter of head and body length.

Species 50. *ALTICOLA STOLICZKANUS* Blanford, 1875. I have never seen the typical race, which was named from the Kuenlun Mountains in Ladak. There is one race in London.

116. *Alticola stoliczkanus stracheyi* Thomas, 1880. Synonym, *"cricetulus"* Miller, 1899. About 14 specimens including the type, examined from east side Mount Everest, Nepal; Rusela, Upper Sutlej; Kyelang and Lingti, in Lahul; Chipchak River, Khardong, Kurram Valley, Mipal Valley, Pandong, and Rupshu, all probably in Ladak, Kashmir. Judging by literature, supposed differences between this form and the earlier named *stoliczkanus* would not appear to be very convincing, or of much importance.

235.(234). M^3 less reduced, with at least three inner salient angles (and three inner folds traceable); tail less shortened, usually exceeding 30% of head and body length.

Species 51. *ALTICOLA ROYLEI* Gray, 1842.

236.(237). Tail, in British Museum material, less than a third of head and body length.

117. *Alticola roylei glacialis* Miller, 1913. Three skins examined from Nahr Nullah in Skardu, Baltistan, 12000 ft. (appx.). These specimens were identified by Hinton in his "Monograph of the Voles and Lemmings," 1926, as *A. r. albicauda* True, 1894, (from Central Kashmir), but they seem to agree more with *glacialis*, at least from description, which is a better known form. The tail color of these skins and the ratio of tail to head and body length agree with *glacialis*, not *albicauda*, which is I think not authentically represented in the British Museum and seems a very imperfectly known form.

237.(236). Tail averages at least a third of head and body length. . . . (238)

238.(241). Bullae relatively small, less than one quarter of occipitonasal length; tail averages less than 40% of head and body length. . . . (239)

239.(240). Ear 13 mm or less in length; underparts less gray.

118. *Alticola roylei roylei* Gray, 1842. About 11 specimens, including the type, examined from Phurkia in Kumaon.

240.(239). Ear 14 mm or more in length; underparts more gray.

119. *Alticola roylei cautus* Hinton, 1926. About 15 specimens examined from Rahla (Kulu Valley) Lahul, 8500–9200 ft.

241.(238). Bullae relatively large, usually approximating a quarter of occipitonasal length, or exceeding it; tail averages more than 40% of head and body length. . . . (242)

242.(243). Length of palate, with one exception in a small series, 13.3 mm or less; length of upper toothrow less than 6 mm.

120. *Alticola roylei blanfordi* Scully, 1880. I provisionally regard "*lahulius*" Hinton, 1926, originally named as a race of *blanfordi*, as a synonym. Hinton and other authors have regarded *blanfordi* as a species, although it is sufficiently closely related to *roylei* to be regarded as a race of that species. True *blanfordi* is so little known that it is quite premature to divide it into supposed races, and the characters for *lahulius* cannot be proved until more specimens come to hand for *blanfordi*. The next form, *montosa*, might well prove to be a synonym of *blanfordi* as well. Including the "*lahulius*" series I have examined about 24 specimens here regarded as *blanfordi*, the type included, from Jagatsukh, Kyelang, Kangra Valley, Koksar, Pattan Valley, Sissu and Zinzingear in Lahul, 10,000–14,000 ft.; also, Nultan Valley in Gilgit, Kashmir.

243.(242). Length of palate, with one exception, 13.4 mm or more; length of upper toothrow most often exceeds 6 mm.

121. *Alticola roylei montosa*, True, 1894. Synonym, "*imitator*" Bonhote, 1905. About 19 specimens, including the type of "*imitator*," examined from Safed Koh, North West Frontier; Kagan Valley, Hazara; Dangail (Kishtwar), Danlong, Gulmerg Gugai, Gugga Nullah, Pahlgahm, Pyas (Kishtwar), Rupal (Astor), Sonemurg, Shenkagalu (Astor), and Tullian, all in Kashmir.

244.(233). Cheekteeth with relatively narrow folds, and crowded appearance.

Genus EOTHENOMYS Miller, 1896

Only one species occurs in India.

Species 52. *EOTHENOMYS MELANOGASTER* Milne-Edwards, 1872. Typically from Szechuan, China. There are two named subspecies in Indian territory, but our material is so poor for both of them that it is almost impossible to offer key characters. Numerous extralimital Chinese races antedate these two names. According to Anthony, who has recently recorded very large series for both races, the characters on which they were based, that is to say dental details, are not constant, and in my opinion in view of this increased knowledge, both races will require redefining. In our very scanty material, they can be distinguished as follows.

245.(246). Tail relatively shorter, about a third of head and body length, or not much more; adult skulls smaller.

122. *Eothenomys melanogaster libonotus* Hinton, 1923. Three specimens, including the type, examined from Dreyi, Mishmi.

246.(245). Tail relatively longer, more than a third of head and body length; adult skulls larger.

123. *Eothenomys melanogaster cachinus* Thomas, 1921. Seven specimens, including the type, examined from Adung Valley, and Mount Imaw Bum, both in North Burma; the latter is the type locality. Probably with a large series of specimens these characters might not prove valid or constant, and perhaps other characters might emerge to distinguish the two forms.

247.(226). Posterior palate terminates with median process converted into sloping septum between postero-lateral pits; inner borders of pits continuous with tip or sides of median process. . . . (248)

248.(257). First lower molar normally with three closed triangles.

Genus PITYMYS McMurtrie, 1831

This is generally recognized only from Europe, Turkey in Asia, and North America. But the subgenera *Neodon* and *Phaiomys*, to which Hinton gave generic rank, and which are currently referred to *Microtus* as subgenera, are clearly subgenera of *Pitymys* if that genus is to be retained. It is only retained, it must be admitted, for convenience. In this genus in the Indian species the species the palate is long, about 60% of occipitonasal length, as in *Hyperacrius*.

249.(254). Bullae proportionately larger, usually more than 6.5 mm in length; foreclaws slightly enlarged; ear reduced, averaging 10–11% of head and body length; tail shorter, averaging less than 30% of head and body length; M^3 strongly reduced, with two folds each side, and a short heel.

Subgenus PHAIOMYS Blyth, 1863

There is only one valid species in this subgenus as here understood.

Species 53. *PITYMYS LEUCURUS* Blyth, 1863.

250.(253). Bullae 7.1 mm. or more in length. . . . (251)

251.(252). Dorsal coloration darker, gray.

124. *Pitymys leucurus petulans* Wroughton, 1911. Three specimens, including the type, examined from Teza, Upper Sutlej Valley.

252.(251). Dorsal coloration sandy and lighter.

125. *Pitymys leucurus leucurus* Blyth, 1863. Synonym, *"blythi"*, Blanford, 1875. Seven Indian specimens examined from Harong Valley, Meruk, Rupshu, above Tsomorin, near Tankse, Tsok Chumo, all in Ladak; also, some extralimital material.

253.(250). Bullae about 6.5 mm in length.

126. *Pitymys leucurus everesti* Thomas & Hinton, 1922. Two specimens, including the type, examined from east side Mount Everest, Nepal, 17,000 ft. This form is very close to *P. l. waltoni* Bonhote, 1905, from Tibet, but may perhaps be retained by its longer palatal foramina. Neither form is well known.

254.(249). Bullae proportionately smaller, very rarely as much as 6.5 mm in length; foreclaws not enlarged; ear larger, averaging about 13% or more of head and body length; tail longer, over 40% of head and body length as a rule; M^3 less reduced, with three inner folds, and two or three outer ones.

Subgenus NEODON Hodgson, 1849

This is close to typical subgenus *Pitymys*, but the form is rather less fossorial, and the supraorbital ridges fuse in the adult, whereas in *Pitymys* s.s. they remain separate.

255.(256). First lower molar with two pairs of confluent triangles in front of the three closed ones; upper toothrow usually more than a quarter of occipitonasal length; bullae relatively smaller.

Species 54. *PITYMYS SIKKIMENSIS* Hodgson, 1849.

127. *Pitymys sikkimensis sikkimensis* Hodgson, 1849. About a dozen specimens, the type included, examined from Changu, Gnatong, Kapup, Kolapokri (Nepal frontier), Lachen and Thangu in Sikkim; Me La in East Bhutan.

256.(255). First lower molar with only one pair of confluent triangles in front of the three closed ones; upper toothrow less than a quarter of occipitonasal length, at least in race inhabiting India; bullae relatively larger.

Species 55. *PITYMYS IRENE* Thomas, 1911. A Chinese species. I have discovered one specimen in the British Museum from North Burma, which may be referred to this species.

128. *Pitymys irene forresti* Hinton, 1923. Typically from Yunnan. This relatively large form is usually given specific rank, but as it is not yet proved to occur with *P. i. irene*, which antedates it, and as the size difference between the two races is average and not absolute, I propose to treat it as a subspecies. One Indian specimen examined from 28.8N., 97.24E. in North Burma. The type is in the British Museum; I have seen several extralimital specimens.

257.(248). First lower molar with four or five closed triangles. (There are five in the Indian species.)

Genus MICROTUS Schrank, 1798

Only one species of this enormous Holarctic genus occurs in Indian territory. It is rather easily distinguished among Indian voles by the fact that the tail normally exceeds half the head and body length. Other Indian Microtinae usually have shorter tails than this.

Species 56. *MICROTUS CLARKEI* Hinton, 1923.

129. *Microtus clarkei clarkei* Hinton, 1923. Six Indian specimens examined from Adung Valley, and 28.8N., 97.24E. in North Burma; also, some extralimital material, including the type, which came from Yunnan.

(*Continued in No. 4*)

THE HELMINTH PARASITES OF COTTONTAIL RABBITS IN ALABAMA, WITH NOTES ON THE ARTHROPOD *LINGUATULA SERRATA*[1]

By Eugenia R. Moore and George C. Moore

Cottontail rabbits are interesting to a great many groups of people. For the hunter, rabbits furnish sport; for numbers of people, they are an important source of food; for the gardener whose greenstuffs they destroy, they are pests; for dogs and other carnivores, they are at once a source of nutriment and a constant danger because of the parasites the rabbits harbor; for doctors and veterinarians, they are important because they are undoubtedly reservoirs for a number of parasites of pathological significance to other animals, including man.

Rabbits are probably more suitable for a parasitological survey than most wild animals. They can be taken with comparative ease, and their prolificacy permits the capture of large numbers without seriously depleting the supply of game and without upsetting the ecological balance to any appreciable extent.

METHOD OF EXAMINATION

Fifty cottontails, *Sylvilagus floridanus* (probably sub-species *mallurus*), were collected in the vicinity of Auburn, Alabama, from March through July, 1939. They were examined for helminth parasites as soon after killing as was practicable. Some were examined immediately; several were kept for a few hours in an electric refrigerator; and the digestive tracts of the others were removed and placed in a preservative liquid shortly after they were killed for subsequent examination. The brain, lungs, heart, kidneys, bladder, liver, diaphragm, and skin of each were examined while fresh or after not more than twelve hours refrigeration.

Routine examination consisted of gross subcutaneous examination, fecal smears from several sections of the alimentary canal, simple salt flotations for determining presence of eggs, and examination of stained blood smears. The brains, lungs, and livers were examined grossly and then teased apart for more critical study. The bronchi and some of the larger bronchioles were examined for roundworms, and the gall bladder and bile duct were opened and examined for parasites. The mesenteries were observed carefully during the removal of the viscera. The contents and the mucosa of the alimentary canal were examined and, in a few cases, the stomach and intestinal walls were preserved to allow study of the lesions produced by parasites.

[1] A thesis submitted by the senior author in partial fulfillment of the requirements for the degree of Master of Science at Alabama Polytechnic Institute, 1939. The authors are indebted to Professor J. M. Robinson, Head, Zoology-Entomology Department, Dr. F. S. Arant of the same Department under whose supervision this work was undertaken. Identifications were verified by personnel of the U. S. Bureau of Animal Industries, Washington, D. C., Dr. Dale Porter of the U. S. Bureau of Animal Industry Regional Laboratory, and Dr. R. O. Christenson of the Zoology-Entomology staff provided literature as well as other valuable assistance.

RESULTS

The largest number of species of parasites found in any one rabbit was nine, collected from an adult male. Eight species were found in each of three rabbits, all adult; and seven were taken from each of four hosts, one about half-grown

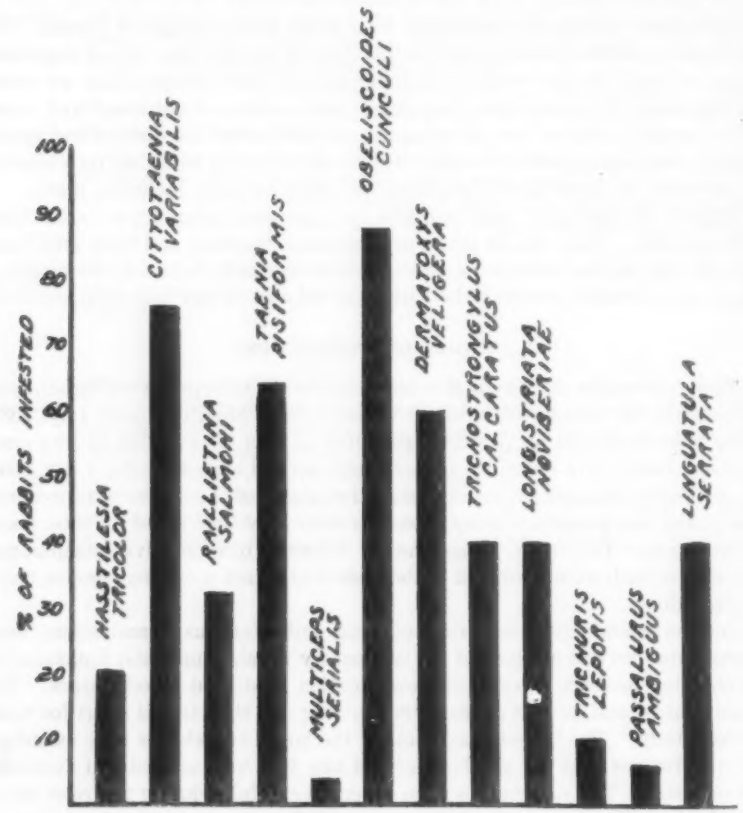

FIG. 1. Relative Prevalence of the parasites from fifty cottontail rabbits collected in the vicinity of Auburn, 1939.

and the others grown. Two rabbits less than one-third grown had no parasites; one nearly the same size had only one, and all the others harbored three or more species. The average number of species of parasites per host was 4.60, the young averaging 3.64 and the adults 5.36 each.

One species of Trematoda, four species of Cestoda, six species of Nematoda, and one species of Arthropoda were collected in this study. The trematodes were present in 20 percent of the cottontails collected; the cestodes in 92 percent; the nematodes in 96 percent and the arthropod in 40 per cent.

Trematoda.—The lone trematode found, *Hassitilesia tricolor*, was taken from 10 rabbits, or 20 percent of the 50 hosts examined. In five infestations, it was found in extremely large numbers in the upper one-third of the small intestine. In no case were less than 30 flukes found in a host. Some were attached to the mucosa or imbedded in it, but the majority of them were free in the lumen of the gut.

Cestoda.—The cestodes were well represented in this survey, since 37 hosts were infested with adult tapeworms and 28 harbored larval forms. All of the rabbits infested with adult cestodes had *Cittotaenia variabilis*, the "broad" tapeworm of rabbits. From 1 to 16 mature worms and from 1 to 33 immature worms were found in each host. In several instances, the lumen of the small intestine seemed partially obstructed by them. Sixteen rabbits were also infested with *Raillietina salmoni*, a much smaller parasite. From 1 to 71 adults were present in each host.

The bladder-like larval form of *Taenia pisiformis* was found in 32 of the rabbits collected, usually in the liver, lungs and visceral mesenteries. In one instance, a large cysticercus was found occupying the cavity of the urinary bladder of its host. Thirty-four was the largest number of cysticerci found in any one host, and the average was about 6 per rabbit. Only two infestations with *Multiceps serialis* were found. One host had a coenurus in the liver; the other had one coenurus in the liver and another in the lungs.

Nematoda.—Six species of nematodes were encountered in this study. No nematodes were found outside the alimentary canal; but in several instances every portion of the digestive tract, from the stomach through the large intestine, harbored one or more of them.

The whipworm, *Trichuris leporis*, was found in the caeca of 5 hosts, all collected from the same area. It was not very numerous in any of them. Twenty-five was the greatest number found in any rabbit, while the average was about 14 worms per host.

Both mature and immature forms of *Obeliscoides cuniculi* were found in the stomachs of the 44 rabbits infested with this parasite. From 3 to more than 100 worms were found in each host, the average being about 30 per host.

Trichostrongylus calcaratus was found in the small intestine of twenty cottontails. Each host had from two to several hundred worms, about 40 being the average number. Three rabbits had estimated infestations of more than 1000.

A species of *Longistriata*, tentatively identified as *L. noviberiae*, was found in 20 rabbits, each host having from 1 to 150 of them. Only two rabbits had more than 50 of these parasites and the average in the others was about 10 each.

The occurrence of *Passalurus ambiguus*, the pinworm of rabbits, was limited to three rabbits collected from the same vicinity. These had extremely heavy infestations. Adults were found attached to the mucosa of the caecum and large intestine while immature forms were found in the small intestine and caecum.

Thirty of the cottontails had *Dermatoxys veligera*. The largest number found in one host was 160, and the average was about 21. Most of these parasites were found in the large intestine, but many were found in the caecum and some immature forms were found higher in the digestive tract.

TABLE 1.—*Summary of helminthological investigations of lagomorphs in North America.*

	HASSTILESIA TRICOLOR	BAILLIETIDA SALMONIS	CITTOTAENIA PECTINATA	CITTOTAENIA VARIABILIS	CITTOTAENIA CTENOIDES	TAENIA PISIFORMIS	MULTICEPS SERIALIS	MULTICEPS PACKI	DERMATOXYS VELIGERA	HEPATICOLA HEPATICA	LONGISTRIATA NOVIBERIAE	NEMATODIRUS TRIANGULARIS	NEMATODIRUS LEPORIS	OBELISCOIDES CUNICULI	PASSALURUS AMBIGUUS	PASSALURUS NONANULATUS	STRONGYLOIDES PAPPILLOSA	SYNTHETOCAULUS LEPORIS	TRICHOSTRONGYLUS AFFINIS	TRICHOSTRONGYLUS CALCARATUS	TRICHURIS LEPORIS
Kansas....						84.0	*														
West Virginia					88.0	60.0								44.0	28.0						36.0
North Carolina	41.46		78.07			37.7								70.73					58.53	80.48	
Oklahoma					23.20	47.9	8.2	1.37					6.80	10.9	20.5						2.7
Texas	*	*		*		*	*						*	*						*	
Alabama	20.0	32.0		76.0		64.0	4.0		60.0		40.0			8.8	6.0					40.0	10.0
West Canada			7.85			14.7	15.6			0.34		25.35				10.7	0.75	83.2			10.7
Alaska			9.3			16.8								0.58		0.58					

* Present but incidence unknown.

Arthropods.—The arthropod, *Linguatula serrata*, commonly called the "tongue worm", was included in this study because of its prevalence in a number of rabbits collected, and because of its wormlike structure and activities. Twenty of the rabbits examined harbored the nymph of *L. serrata*. There were several heavy infestations, one host having 65 nymphs in the mesenteric ganglia, 11 in the liver and more than 75 in the lungs. The average number per host was about 35, exclusive of prenymphal stages and calcified forms.

THE PARASITES AND SUMMARY

Fifty cottontail rabbits, *Sylvilagus floridanus*, were collected at Auburn, Alabama, from March through July, 1939, and were examined for helminth parasites and for the wormlike arthropod, *Linguatula serrata*. The percentage of rabbits in which each was found are as follows: *Obeliscoides cuniculi*, 88 percent; *Cittotaenia variabilis*, 76 percent; *Cysticercus pisiformis*, 64 percent; *Dermatoxys veligera*, 60 percent; *Longistriata* sp. (probably *noviberiae*), 40 percent; *Trichostrongylus calcaratus*, 40 percent; *Raillietina salmoni*, 32 percent; *Hassitilesia tricolor*, 20 percent; *Trichuris leporis*, 10 percent; *Passalurus ambiguus*, 6 percent; and *Multiceps serialis*, 4 percent. The Arthropod, *Linguatula serrata*, was more prevalent than many of the helminths, being found in 40 percent of the rabbits.

COMPARISON OF THIS STUDY WITH SIMILAR SURVEYS

The results of this study were compared with those of investigators from several parts of the continent. In 1915 Ackert collected 64 cottontails from the vicinity of Kansas State Agricultural College; E. W. Price (1928) listed the parasites of the domestic rabbits of Texas; Boughton (1932) conducted an examination of 420 snowshoe rabbits from western Canada; Weimer, Hedden and Cowdery (1934) examined 25 wild rabbits (*Sylvilagus* sp.) from West Virginia; the parasites of wild rabbits (both jack rabbits and cottontails) of central Oklahoma were studied by Ward (1934); Harkema (1936) examined 41 cottontails in Durham County, North Carolina; and Philip (1938) examined 172 varying hares from Alaska. Details of these surveys are found in Table 1. The results of investigations in Alabama corresponded more closely, both in species of parasites and their prevalence, to surveys made of rabbits in the southeastern part of the United States than to those further removed.

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BIOLOGY OF THE DERMESTID BEETLE WITH REFERENCE TO SKULL CLEANING

BY WARD C. RUSSELL

Since our last report (Jour. Mamm., vol. 14, pp. 372–374, 1933), on the use of dermestid beetles, *Dermestes vulpinus*, for cleaning bones, the Museum of Vertebrate Zoology has received many requests for samples of this beetle and questions on details of their use. Since our "bug"-room technique has undergone considerable change, a summary of information to date seems timely. The beetles, commonly called bugs by museum workers, will be so referred to here.

Notes on their life history were taken with the hope of better utilizing their capabilities as bone-cleaners. At the time the life history observations were made, we considered a warm room essential. For this reason the following information on life history concerns bugs kept at 85°F. The adults were confined separately or by pairs in small jars in the bug room and were examined at 8:00 a.m. daily. One-inch cubes of roasted sheep-tongue were used for food.

When the adult beetle emerges from the pupa, its color pattern is different from the familiar black and white. The anterior part of the head, the antennae, and the joints of the legs are dark red; the posterior part of the head and the legs are yellow. There are three orange dots on the elytra anteriorly and one on the head posteriorly. The mouth parts are also orange. The elytra are light gray, the wings colorless, and the under surface reminds one of cream-colored velvet. The permanent color scheme, of dorsal black and ventral white, appears at the end of two days after the bug has gone through a gray, yellow, pale-red, and dark-red phase.

The bugs begin to eat on the third day, and on the fifth day the first eggs are laid. Females confined separately occasionally lay a few malformed eggs, but the introduction of a male stimulates egg production, usually within 24 hours. The ability to produce eggs varies greatly among individuals. Some lay 1 to 5, others 20 to 30, eggs a day; 72 was the largest number known to be deposited by one female in a 24-hour period. The average production for some of the better layers was 426 eggs during 100 days of life. However, most of the eggs are produced during the first 60 days. The eggs hatch in 3 days, and the larvae pass through eight instars in the next 30 days. The first 20 larval days are a period of rapid growth and constant eating, hence the time of maximum bone-cleaning. The 20th to 25th days are spent excavating a site in meat or wood to provide a safe place to pupate. In the last five days the larva loses the power

of locomotion and finally sheds the larval skin, which effectively blocks the entrance to its burrow. Larvae that are forced to pupate in the open are susceptible to attack by other beetles, although the loss observed has never been high. For seven days the pupa remains dormant, the only noticeable change being a slight darkening in color as the time for emergence approaches. The pupal skin is shed by spasmodic movements of the abdomen and legs, ecdysis requiring approximately one-half hour. Thus we find that the complete cycle is 45 days per generation, divided as follows: egg 3 days, larva 30 days, pupa 7 days, and adult 5 days before laying.

Maximum egg production, so essential for a thriving bug colony, is dependent on the water and fat content of the meat and on crevices for the deposition of eggs. Skeletal material that has lain around for years is usually too desiccated to start a colony. Conversely, fresh meat must be sufficiently dry to prevent maceration, molding, or the liquefying of fats. Eggs saturated with oil will not hatch. Meat with fat adhering to the surface or interposed between the muscles bundles provides a balanced diet. The flesh of a sea bird, skunk, opossum, squirrel, or racoon affords good material, but the breast muscles of gallinaceous birds or the flesh of a lean wildcat is poor in this respect. Bugs restricted to a diet of lean, very dry meat lay few eggs; the larvae are sluggish and dull in color, and those that survive eventually produce adults about one-half natural size. If, however, these undersize adults are given meat with fat present, they will produce many active, glistening larvae which emerge as adults of normal size.

As previously mentioned, one-inch cubes of roasted sheep-tongue were used for food. These pieces of meat, when dry, present smooth surfaces unsuited for the deposition of eggs. On this meat the bugs would lay 1 to 5 eggs per day. However, these same pieces of meat when slit with a sharp knife stimulated egg production immediately and resulted in 20 to 30 eggs per day. If these slits are too tight, the insertion of the ovipositor is apparently prevented, while if they gape, they present another smooth surface and are not utilized. It was found that sheet cotton used to cover specimens provides an excellent substitute as a hiding place for eggs. This cotton apparently is a satisfactory substitute for the feathers or fur in which many eggs are deposited under natural conditions.

During the recent war, the Museum received so few fresh specimens that it became desirable to slow down the tempo of the bug room but still maintain a supply of bugs readily available for small jobs. The solution of this problem came quite by accident. The bug room was infested with spiders, and while work was slack, the room was washed and fumigated. A new colony of bugs was started on sheep heads in a large, tin box. This box was kept in the preparator's room at ordinary room temperature, 65°–70°F. More time was required to produce a working colony, the eggs hatching in seven days instead of three, but once the colony was established specimens were cleaned as readily as when the bugs were kept warmer. An advantage in this arrangement is that the colony can be maintained on much less meat.

The fact that a balance must be maintained between the meat used for repro-

ductive purposes and the specimens to be cleaned is generally overlooked. And this I believe is the reason that many small colonies are unsuccessful. The average small specimens, skulls or skeletons, do not possess the three requisites for maximum egg production, namely fat, proper moisture-content, and hiding places for the deposition of eggs. This balance is as vital in a bug colony as the relation between plants and animals in an aquarium. We have found that sheep heads are most satisfactory for propagating bugs. They are always available at a slaughter house and can be purchased with brains removed. When roasted in an oven and then air-dried, they can be stored and used as needed. Flies should be kept away.

For housing, a metal container is essential. A wooden box will be destroyed by larvae seeking places to pupate. Glass is satisfactory if light is excluded. The dimensions of the box depend upon the amount of material to be cleaned. A box 36″ x 24″ will accommodate a large colony. A small colony can be housed in a container the size of a five gallow can. A free circulation of air at all times is important. A lid of fine mesh should be used, and never one that is solid.

Twenty-five beetles caught at random beneath a carcass found in the field is sufficient to start the colony. Dermestid beetles are widespread, easy to find, and, contrary to a prevalent notion, not endemic to the Museum of Vertebrate Zoology! Wrap two sheep heads in one layer of sheet cotton (not absorbent cotton), place in the box, and add the beetles. Cover with the screen lid and leave for two months. By then, the first and second generations of bugs will have almost cleaned the heads. This is the time to introduce the first specimens to be cleaned. Do not remove the sheep heads. These act as a reservoir from which the bugs migrate to specimens to be cleaned. Also the bugs can retreat to these when the specimens are completed. One sheep head per month will keep the colony active when there is nothing to be cleaned. Fewer heads are required as the volume of skeletons and skulls to be cleaned increases.

The success of bugging operations is dependent largely upon the proper care of the specimens at the time of collecting. There is an all-too-prevalent idea among collectors that, while skins should be handled with care, any treatment is good enough for bones. Observe the following rules of good preparation to insure efficient bugging:

1. Do not allow sawdust, or other materials used in skinning, to dry on the bones.
2. Keep bones entirely free of arsenic, salt, or formalin.
3. Keep flies from blowing the fresh specimens.
4. Quick drying (of fresh material), either naturally or by artificial means, avoids maceration and subsequent discoloration of bones. This also prevents the growth of mold, a strong bug-repellent.
5. Remove the brains from all skulls before hanging them up to dry.

As a liquid or in the form of humid air, water is not recommended. Humid air favors the growth of mold on meat, and bugs confined in a small box with moldy meat will die. Fresh specimens, not dried, or those that have been soaked in water can be bugged, and this may be done rapidly too. But one must be

certain that there are enough bugs to do the work in 12 hours or less. If there are not enough bugs to complete the cleaning in this time, maceration of the meat may result. Specimens preserved in formalin or alcohol, or covered with arsenic, salt, alum, etc., can be bugged if partly cooked and if offered while still damp. To produce well articulated skeletons, and for the safety of skeletons of very young animals, the carcass must be thoroughly dry when given to the bugs; and it should be bugged slowly. It is better to place such a specimen in a separate container and add a limited number of small larvae. For example, to bug the skull of a newborn *Microtus*, place the specimen in a skull vial and add two or three newly hatched larvae. When these have grown to 5 mm in length, replace them with small ones.

A summary of recommendations for the management of a balanced bug colony is as follows:

1. Use a metal container, provided with a screen lid.
2. Keep in a dark place at a temperature of 65–70°F.
3. Provide dried sheep heads in addition to specimens to be cleaned.
4. Be certain that all meat given to the bugs is dry and free from maggots or chemicals.

Museum of Vertebrate Zoology, Berkeley, California.

A NEW SUBSPECIES OF BADGER FROM THE STATE OF IOWA

By Viola S. Schantz

In searching for badger specimens from the state of Iowa in the numerous museums, through correspondence or visits to these institutions, I was disappointed to find only two specimens which I recognized as quite different from the Wisconsin and Minnesota badger, *Taxidea taxus jacksoni*, and the Badlands badger from South Dakota, *Taxidea taxus dacotensis*. Recently, through the cooperation of the Division of Game Management, Fish and Wildlife Service, two more specimens were collected in Sioux and Wright Counties, Iowa, for the Biological Surveys collection. These substantiate my previous findings and I describe this new form as follows:

Taxidea taxus iowae, subsp. nov.

Type.—No. 275169, U. S. National Museum, Biological Surveys collection; young adult male (coronal sutures fused), skin and skull; collected near Clarion, Wright County, Iowa; December 8, 1946, by Harry T. Maltby. Original no. 1; Biological Surveys miscl. no. 32525X.

Distribution.—Known only from Iowa. Upper Austral life zone, Carolinian Fauna. Illinoian biotic province (Dice).

Diagnostic characters.—Body has silvery, black, and very light cinnamon drab appearance; bullae more inflated and molars larger than in *T. t. jacksoni*.

Color.—Type, winter pelage: Face, forehead (except median line) and patches on sides of face in front of ears black as customary in the species, but hairs on forehead slightly tipped with gray; eyes black; white irregular markings under and behind eyes merge with

light buffy under parts; ears blackish; general dorsal area and sides of body have a mouse-drab underfur shading into very light cinnamon-drab, with hairs widely banded with black subterminally and conspicuously tipped with silvergray, producing a mixed grayish, black, light cinnamon-drab appearance, with gray and black colors predominating; median white line extends from middle of face to near shoulders; vibrissae and area above median line blackish; chin slightly brownish; general abdominal area light buff; limbs brownish black; upper side of tail with cinnamon underfur, the black guard hairs tipped silver-gray, and tail terminating with black tip; underside of tail with cinnamon underfur and black guard hairs.

Skull.—Averages the same size as *jacksoni*, but auditory bullae more inflated and molars larger.

Measurements.—Type: Total length, 787 mm; tail vertebrae, 152; hind foot, 114. Skull: Supraoccipital and condyles missing. Approximate condylobasal length, 128; zygomatic breadth, 76.5; mastoidal breadth, 78; interorbital breadth, 28.5; postorbital constriction, 28.5; palatal constriction, 15.2; palatal length, 65.5; maxillary toothrow (alveoli), 43; crown length of upper molar, 13.8; crown width of upper molar, 11.

The only other skin measurement available is that of an adult female taken near Alton, Iowa: Total length, 710; tail vertebrae, 140; hind foot, 102.

Average and extreme cranial measurements of three males are as follows: condylobasal length, 128 (128–128.5); zygomatic breadth, 76.5 type only (others are broken); mastoidal breadth, 78.3 (78–78.5); interorbital breadth, 29.7 (28.5–32.2); postorbital constriction, 28.7 (28.2–29.5); palatal constriction, 14.5 (13.6–15.2); palatal length, 63.6 (62–65.5); maxillary toothrow (alveoli), 42.3 (41.9–43); crown length of upper molar, 13.4 (13.2–13.8); crown width of upper molar, 10.2 (9.7–11). Adult female smaller: condylobasal length, 119.5; zygomatic breadth, 79.6; mastoidal breadth, 70.6; interorbital breadth, 27; postorbital constriction, 27.2; palatal constriction, 14; palatal length, 58.7; maxillary toothrow (alveoli), 40.6; crown length of upper molar, 13.5; crown width of upper molar, 10.6.

Weights.—The weights of two males, 16½ pounds (type) and 22 pounds (Ogden, Iowa); female, 15 pounds (near Alton, Iowa).

Remarks.—While these specimens were taken at various localities in Iowa, they represent fairly constant external characters in that they are much paler in appearance than *jacksoni*, and very much darker than *dacotensis*.

Specimens.—Total number 4 from Iowa as follows: Alton (near), Sioux County, 1 (skin and skull); Clarion (near), Wright County, type locality, 1 (skin and skull); Ogden, Boone County, 1 (skin and skull) Iowa State College collection; Quasqueton, Buchanan County, 1 (skull only).

Biological Surveys, U. S. Fish and Wildlife Service, Washington, D. C.

GENERAL NOTES

SIGHT RECORDS OF THE WEST INDIAN SEAL, MONACHUS TROPICALIS (GRAY), FROM THE TEXAS COAST

According to Allen (1942), the range of the West Indian seal seems to have included the Gulf of Mexico and Caribbean Sea as far south as the coast of Honduras, eastward to Jamaica, Cuba and Hispaniola, thence northward throughout the Bahamas. It used to be present on the south Florida coast and as late as 1922 (Townsend, 1923) one was killed near Key West. Apparently that is the last printed report of a living specimen. The Alacranes Islands and Triangle Keys off the coast of Yucatan have been the last remaining stronghold of the species (Allen, *op cit.*). It is possible that some still remain there. No seals from the Texas coast have been reported in the literature.

In 1941, J. U. Rogers, a long-time observer of marine life around Galveston, Texas, told me that during the year 1932, or thereabouts, several sea lions or hair seals stayed for a period of six weeks or so near the jetties of Bolivar Pass, the ship channel and main pass into Galveston Bay, and that they often crawled out on the rocks. This account was surprising to the writer, but since it was in the unverifiable past, I did nothing about it except write Dr. Remington Kellogg and suggest that possibly seals had been seen on the Texas coast as recently as 1932.

On May 15, 1946, Dr. J. M. Hockaday, Mayor of Port Isabel, the southernmost town of the Texas coast, told me that a seal had been seen several years ago in the lower Laguna Madre by members of the U. S. Engineer Office, of Brownsville. Coming on top of the previous report from the other end of the Texas coast, to which I had not paid much attention, it aroused my deep interest and I went to see the men.

Mr. James F. Jennings told me that during the fall of 1932 members of the crew of the U. S. Engineer boat, which was working in Brazos Santiago Pass, saw a marine animal several times over a period of two or three months, which crawled out on the jetties of the pass occasionally. Mr. Jennings saw the beast only one time. He said it was about 5 feet long, appeared to weight about 150 pounds and was a light chestnut brown in color. It slipped back into the water when the boat approached to within about 100 feet. He thought the animal had whiskers, but could not be sure. He and the other members of the crew called it a "land porpoise." When I asked whey they did not think it was a seal, he said they "thought seals lived around the North Pole" and never got into the Gulf, so a "land porpoise" was the best designation they could think of. However, Captain Curtis Everson, who was in charge of the boat and who had travelled widely over the seas of the world, told them the animal was a seal. Captain Everson, since deceased, was the only member of the crew who took a great deal of interest in the seal and every time the boat went out he was on the lookout for it. Mr. Jennings said members of the crew used to tease Captain Everson, saying, "That's no seal, Cap.; that's a mermaid."

Mr. Tom Forman, civilian engineer in charge of the Brownsville office of the U. S. Engineer Office, was emphatic in stating that an animal he saw in Brazos Santiago Pass in 1926 was a seal. He said it came to the surface within 10 or 15 feet of him. It was a light yellowish brown in color and he could see that it was covered with short hair. He added that several times the animal had been seen by other people near the municipal pier of Port Isa bel in the Laguna Madre.

Mr. Jennings and Mr. Forman told me that Mexican fishermen had reported seeing seals far down the Mexican Gulf coast "where rocks run out into the water." I was unable to locate any of these men and do not know where the locality is or in what years the seals were reported.

It has been suggested to me that what the men who reported seals in Texas waters really saw were manatees. However, several facts make that conclusion untenable. In the first place the observers are all intelligent men and impressed me as being very careful in relating the instances. Secondly, the men at Brownsville are acquainted with manatees, which

have been seen in the lower Laguna Madre several times in the past (Gunter, 1941). Manatees are much larger than the animal described and they are unable to crawl out of the water. The descriptions given fit seals only. The West Indian monk or hair seal is the only member of the Order Pinnepedia known to have inhabited the Gulf of Mexico or Caribbean Sea within the recent era.

From these facts it seems justifiable to conclude that the West Indian seal, *Monachus tropicalis* (Gray), has been seen at widely scattered points on the Texas coast as recently as 1932.

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SPERMOPHILES AND BADGERS MOVE EASTWARD IN OHIO

The recent capture of a large male badger, *Taxidea t. taxus* (Schreber), and the collecting of a male spermophile, *Citellus t. tridecemlineatus* (Mitchill), from one of several colonies of these ground squirrels in Knox County, Ohio, at the border of glaciated territory and east of the Allegheny Front Escarpment, may be of interest to students of mammalian distribution. Neither of these prairie animals had been reported in the vicinity of my parents' home in Pike Township, Knox County, prior to my entry in the armed services in April 1942. Upon returning from the Army late in the year 1945, however, I learned that spermophiles had been seen by several Pike Township farmers and on June 8, 1946, a large male badger was captured in the western part of the township.

During the summer of 1946, several spermophiles were seen in making week-end visits to the home of my parents near North Liberty, Ohio, in Knox County. By questioning farmer friends, I was able to learn that spermophiles were first observed in this vicinity in the summer of 1942 when cats brought in striped "squirrel-like animals" that these farmers had never seen before. Visits in July and August 1946, to two farms about two miles west of North Liberty revealed that active colonies were still present. A male spermophile was collected on one of these farms August 17, 1946, and is now in the collection of the Ohio Cooperative Wildlife Research Unit.

Other spermophile colonies were noted to the east of North Liberty and the spermophiles were reported as being numerous in the cemetery at Amity, Ohio, in the southeast corner of Pike Township. I did not see any of the animals when I visited the cemetery July 26, 1946, but I saw several freshly used burrows.

On August 18, I was able to trace the presence of spermophiles by questioning farmers, to the very edge of the Illinoian glaciated section of Ohio. It was interesting to note that the dates given for first observations of the spermophiles by farmers became progressively more recent as I drove north and eastward from North Liberty. For example, Mr. J. B. Jefferson, who lived in Brown Township near College Hill, one mile south of the Richland-Ashland County line, reported having seen the animals for the first time in 1945. Several miles to the north in Richland County, my brother, Leland Leedy, reported that a cat had brought a spermophile to his home in the spring of 1946. This was the first one he had seen on his farm in sections 8 and 17 of Worthington Township, about one and one-half miles north of Butler. Farther east in the unglaciated Allegheny Plateau area, farmers interviewed had as yet not seen any "gophers."

Robert Goslin (1934) indicated that the eastern striped spermophile seemed well established in Fairfield County and had invaded the glaciated plateau area of central Ohio approximately 10 years before they were observed in the North Liberty-Butler area. The

latter area is approximately 60 miles north and slightly east of Fairfield County. Subsequent to Goslin's report, Norman Preble (1942) located several colonies of spermophiles in Chester Township in the southeastern part of Morrow County and another colony two miles west of Fredericktown in 1939.

The presence of spermophiles in northern Knox County and southern Richland County fulfills Goslin's prediction that they would extend their range to the north and northeast. It is interesting to speculate whether they will become well established in the unglaciated Allegheny Plateau immediately east of their present range. Most of the Morrow and northern Knox County colonies are located on gravelly morainal pasture lands which at one time were cultivated but now, after serious soil losses due to erosion, are permitted to lie relatively undisturbed. If not too severely eroded these hill pastures are composed primarily of timothy (*Phleum pratense*), bluegrass (*Poa compressa* and *Poa pratensis*) and white clover (*Trifolium repens*). Farther east in the unglaciated plateau more of the pastures contain broomsedge (*Andropogon virginicus*), poverty oat-grass (*Danthonia spicata*), and a larger percentage of the land is wooded. In territory crossed by railways, it is possible as suggested by Goslin (letter September 25, 1946) that spermophiles may spread by means of this type of man-made habitat. In the northern Knox County area however, no railways are present.

With the spreading of the spermophiles to the eastward, at least two badgers have been captured recently far beyond their usual range in Ohio. It is interesting to speculate whether the extended range and apparent increase in abundance of spermophiles have been a factor in the extension of the range of the badger. It is well known that badgers utilize spermophiles as food.

In May 1945, a male badger was killed by a farmer and his dog just north of Columbus, Ohio. The capture of this badger was reported by Charles A. Dambach in the Ohio Wildlife Research Unit's column "Knowing Ohio Wildlife" in the July 1945 issue of the Ohio Conservation Bulletin (vol. 9, no. 7, p. 27). The skull is in the Ohio Wildlife Research Unit's mammal collection.

In the evening of June 8, 1946, my brother Russell Leedy and his friend, Glenn Stone, were attracted by the barking of their hound near the Eagle Grove School in western Pike Township, Knox County, Ohio. Upon going to the dog, they found him barking at a badger. In spite of the activities of the large hound which had overtaken the badger on the surface of the ground, the badger almost succeeded in burrowing into the ground and escaping. It was taken alive, however, and found to be a very large male weighing about 25 pounds. Diggings and tracks had been seen earlier in the spring in the vicinity of its capture leading to the belief that a badger might be present. There was no indication that the animal had been released or had escaped from a traveling menagerie. The badger is being kept alive at present by a Knox County farmer who says the animal is observed weekly by many interested spectators. It is understood that it will be presented eventually to the Ohio Cooperative Wildlife Research Unit for a study specimen.

The Knox County specimen was taken more than 100 miles southeast of the Williams-Lucas-Henry-Fulton County area of northwestern Ohio which is the only area of Ohio in which badgers can be considered fairly common.

More than a decade ago, Mosely (1934) reported on the increase of badgers in northwestern Ohio and stated that he had data on nearly 70 badgers caught or killed in that part of Ohio before 1934. He also had reports of two badgers near Williard, Ohio, in 1930 and of a badger being trapped near Mt. Victory, about 80 miles south of Toledo in 1933. Goslin (*in litt.*, 1946) recalled that a badger had been killed by a car near Stoutsville, Fairfield County, in December 1929. Unfortunately, this badger was taken to a local taxidermist and was not secured for a scientific specimen.

Many of the badgers caught or killed in Ohio are preserved as mounted specimens by the men who capture them rather than being sold for their fur value. There are seldom recorded more than 10 to 12 badgers in the annnual Ohio Fur Dealers' Reports. They are still rare enough in Ohio to be regarded with a considerable amount of curiosity and are

killed at every opportunity. Whether the occasional badgers that emigrate from the sandy areas of northwestern Ohio to the south and east will be able to establish themselves firmly remains unknown.

Acknowledgements are made to Dr. Edward S. Thomas of the Ohio State Museum, Dr. Lee E. Yeager and Miss Viola S. Schantz of the Fish and Wildlife Service, and Mr. Robert Goslin for suggestions in the preparation of this note.

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DANIEL L. LEEDY, *Ohio Cooperative Wildlife Research Unit, Ohio State University, Columbus 10, Ohio.*

AN UNUSUAL WINTER RECORD OF CITELLUS SPILOSOMA IN OKLAHOMA

Only one juvenille female *Citellus spilosoma major* (Merriam), weight 62 grams, measurements: 185, 63, 31, and ear from notch 8 mm., was taken in a total series of 16,210 trapnights during three winter seasons on the Southern Great Plains Experimental Range three miles north of Fort Supply, Oklahoma. No specimen was taken between November 22 and December 28, 1940, by A. H. Trowbridge in 4,460 trapnights; one specimen only was taken on November 29 during the period November 25 to December 19, 1941, in 7,430 trapnights by A. H. Trowbridge and the writer; and again no specimen was taken by the writer in 4,320 trapnights during the period December 10 to December 22, 1942. In the above periods, the areas trapped included 89 one-half acre quadrats, 12 one-acre quadrats, 1 two-acre quadrat, and 13 traplines 165 feet long. Early summer trapping operations in 1942 indicated the spotted ground squirrel population to vary from one to three animals an acre depending on the experimental pasture. A. H. Howell in his *Revision of the Ground Squirrels*, North American Fauna No. 56, 1938, p. 21, mentions "Hibernation in this species is apparently not complete, at least in the more southern parts of its range, but during severe winter weather the animals usually remain within their burrows." Apparently this subspecies is only rarely active during the fall period, and it appears to be in complete hibernation during the winter months on the sandy-sage lands of western Oklahoma and eastern Texas. This may or may not apply to its entire more northern range.

As the adults usually precede the young-of-the-year into hibernation, the late activity of this young female and the absence of other adults or juveniles would also indicate that the female came from an unusually late brood.—FRANK B. MCMURRY, *Fish and Wildlife Service, Cache, Oklahoma.*

RECORD OF LYNX CANADENSIS CANADENSIS IN NEVADA

Recently after reading through the "Hypothetical list of mammals possibly occurring in Nevada", on page 643 of *Mammals of Nevada* by E. Raymond Hall (1946), I examined our *Lynx canadensis* collection to make sure whether or not we had any specimens from Nevada. I found one specimen that had been overlooked and that should be reported since it is apparently the first record from the state.

This specimen, a tanned skin and skull, of an adult male no. 223441 Biological Surveys collection, original number 77 (14851-X), was collected June 27, 1916, by J. R. Bunch on the Little Owyhee River, which flows through the northeastern part of Humboldt County and continues through the northwestern part of Elko County, at 117° W. longitude, and 41° 55′ N. latitude. The specimen is in excellent condition and has all the characteristics of

Lynx canadensis canadensis.—Viola S. Schantz, *U. S. Fish and Wildlife Service, Washington, D. C.*

A RECORD OF SOREX MERRIAMI MERRIAMI FOR SOUTHEASTERN WYOMING

On December 14, 1946, Charles N. Steele, Jr., collected an adult male of *Sorex merriami merriami* Dobson, weighing 4.2 grams, on an earth embankment along the highway between Laramie and Woods Landing, 3.6 miles, by car speedometer, southwest of the city limits of Laramie, Albany County, Wyoming. The altitude at that spot, obtained by sensitive altimeter, is 7,190 feet.

Along the highway at that point a drainage ditch has been dug in the barrow pit and the excavated dirt thrown out on the side away from the highway. Embankments thus formed are almost bare of vegetation, but some parts have a sparse growth of rabbit brush, sweet clover and a few other plants. There is some grass among the weeds along the ditch and enough water (frozen at that time) in the bottom of the ditch to make it suitable for a growth of narrow-leafed cattails. This shrew was captured at a point on the bare, steep slope at the north end of the series of embankments, which was 32 feet, in a straight line, from the edge of the ice. The Merriam shrew has been described as a species of arid regions, so we thought the capture of this specimen near water was worthy of mention.

Deer mice were common in the area, a harvest mouse was collected among the weeds, montane meadow mice were collected in the grassy border along the ditch, a dusky shrew was trapped in the meadow mouse runways, a striped skunk was trapped at the entrance to a nearby culvert, and there were signs of muskrat among the cattails. The fact that the two species of shrews were collected at points so close together was of interest to us.

Identification of the specimen has been confirmed by E. R. Hall of the Museum of Natural History, University of Kansas, Lawrence, Kansas. He thinks this possibly marks the southeastern limit of range of the species.

Benson and Bond in their "Notes on Sorex merriami Dobson" (Jour. Mamm., vol. 20, pp. 348–351, 1939) state that only 18 shrews of the species were then known to be extant. They give six localities for *Sorex merriami merriami*: 1 in Montana (type locality), 1 for western North Dakota, 1 for southwestern Washington, 1 for Oregon, 1 for northern California, and 1 for northern Nevada. Five localities are given for *Sorex merriami leucogenys*: 2 in Utah (including type locality), 2 in Arizona, and 1 in Nevada near the California-Nevada border.

Hooper (Jour. Mamm., vol. 25, p. 92, 1944) records the capture of two additional specimens of *S. m. merriami* from Montana. This specimen is apparently the twenty-first individual to be taken and the first from Wyoming. It makes quite an extension to the known range of the species.—Arthur B. Mickey and Charles N. Steele, Jr., *University of Wyoming, Laramie, Wyoming.*

CURIOUS BEHAVIOR OF A HOARY BAT

At 10:20 p. m., September 9, 1946, Mr. and Mrs. John Lindner were walking on the highway near their summer cottage at the head of Canandaigua Lake, New York. It was dark and they were startled by a noise at their feet and by a dark object that struck the legs of Mrs. Lindner. The dimly seen object was believed by them to be a snake and I was asked to investigate. As we approached the spot, perhaps fifteen minutes later, I was also startled by a chattering noise and by something that seemed to bounce to a height of about 18 inches above the pavement. The beam of my flashlight revealed the "dark object" to be a hoary bat, *Lasiurus borealis*, which continued to bounce several times while exposed to the light, then settled down on the pavement, and grasped in its jaws, the mutilated body of a small pipistrelle, *Pipistrellus subflavus obscurus*.

When picked up by the nape of its neck, the larger bat clung momentarily to the body of its smaller relative. Both specimens were taken and the pipistrelle was found to be bleeding from fresh wounds about the head and shoulders. It was quite evident that the hoary

bat resented the close approach of anything that interfered with its feeding for it twice demonstrated its displeasure by voice and actions and refused to abandon its prey.—SHERMAN C. BISHOP, *Department of Zoology, University of Rochester, Rochester, New York.*

A RECORD OF A TIMBER WOLF ATTACKING A MAN

Stories of wolves (*Canis lupus*) attacking humans have been prevalent, especially in the north country, but few, if any, have been investigated sufficiently to establish them as undoubted facts. In checking many such stories Young (Young and Goldman, 1944, *The Wolves of North America*, pp. 128–149) has compiled most of the available data on the subject. Most cases, however, leave much to be desired in the way of indisputable proof backed by thorough investigation. Since it is so difficult to establish such facts by thorough investigation, it seems desirable to put on record an account of such an attack recently called to my attention.

The original investigation was made by Mr. Vincent Crichton of Chapleau, Ontario, Wildlife Specialist for the Fish and Wildlife Division of the Ontario Department of Lands and Forests.[1] I know him to be a competent and reliable observer with much field experience. He checked the report soon after its occurrence and in his investigation he obtained sworn statements from the man who was attacked and the three men who were actual witnesses. These statements followed by Mr. Crichton's original account are listed in order that the unaltered facts be presented.

"I, Mike Dusiak, Canadian Pacific Railway section foreman at Poulin, Ontario, where I have worked for the C. P. R. for 31 years, voluntarily give this statement to V. Crichton, an officer in the Dept. of Game & Fisheries and do swear that it is true in every detail and that it will have the same effect as if given under the Canada Evidence Act.

"While patrolling my section of the railway on Dec. 29/42 at about 8:15 a.m. on my speeder, going east to Poulin from my home at Devon which is about three miles west of Poulin, equipped with two axes and a rail wrench, I came to mileage 128 and knowing that a west bound train was coming and might be close, I was keeping a careful watch while travelling at about ten miles an hour on the speeder. Suddenly something hit me and grabbed me by the left arm. It came so fast and was such a blow that it pulled me and the speeder from off the track by the impact on to the south side of the rails. It happened so fast and as it was still very dark, I thought an engine had hit me first. After getting up from out of the snow very quickly, I saw the wolf which was about fifty feet away from me and it was coming towards me. I grabbed the two axes, one in each hand and hit the wolf as he jumped at me right in the belly and in doing so lost one axe. Then the wolf started to circle me and got so close to me at times that I hit him with the head of the axe and it was only the wielding of the axe that kept him from me. All this time he was growling and gnashing his teeth. Then he would stop circling me and jump at me and I would hit him with the head of the axe. This happened five times and he kept edging me closer to the woods which was about 70 feet away. We fought this way for about fifteen minutes and I fought to stay out in the open close to the track. I hit him quite often as he came at me very fast and quick and I was trying to hit him a solid blow in the head for I knew if once he got me down it would be my finish. Then in the course of the fight he got me over onto the north side of the track and we fought there for about another ten minutes. Then a west bound freight train came along travelling about thirty miles an hour and stopped about half a train length west of us and backed up to where we were fighting. The engineer, fireman and brakeman came off the engine armed with picks and other tools, and killed the wolf. When the engine crew got off the engine I was no more afraid and fell into the snow from exhaustion. I could not have lasted very much longer as I was very tired. They asked me if I was hurt and I said no only tired and then they asked me to go into Chapleau

[1] An article based on Mr. Crichton's account, written by Mr. Harold Devine, appeared in the July issue of *Outdoor Life*, 1943.

with them, but I said I was only tired and was going to work. There were no scratches or marks on me as the wolf only had a hold of me once and that was when he first attacked and had me by the sleeve of the left arm. I did not trap or snare this wolf or shoot at him, as I do not trap or carry a gun."

Signed: Mike Dusiak
Poulin, Ontario
January 12, 1943

Statement of Witnesses

"Coming up as the engine crew on through freight No. 951 on the morning of December 29/42, we saw a wolf attacking a sectionman whom we identified later as Mike Dusiak. We stopped the train and we got off armed with a shaker bar and a coal pick and killed the wolf as it stood about 15 feet from Dusiak who by this time was sitting in the snow, exhausted and trembling. Dusiak could not speak at first but then told us this wolf had attacked him as he was coming along on his speeder."

Signed: W. Somers, Engineer, Chapleau, Ontario
Jack Green, Fireman, Chapleau, Ontario
John Way-White, Brakeman, Chapleau

Statement of Investigator

"On December 29th 1942, at about ten a.m., I was informed that a wolf had attacked Mike Dusiak, section foreman at Devon, at a point approximately 12 miles west of Poulin siding on the Canadian Pacific Railway.

"I went to Poulin and arrived there at about 11:00 a.m. and contacted Mike Dusiak and he informed me that a wolf had attacked him that morning on his way to work from Devon. He had the dead wolf in the sectionmens shack at Poulin and I had a thorough look at it. It was not an old wolf. Had every tooth in its head and in good condition but like all wolves, it was not fat, but lean.

"After Dusiak explained his story to me, he took me to where the wolf attacked him which was about 1½ miles west of Poulin.

"There in the snow was the undisputed signs of a struggle between man and a wolf. The wolf had come out of the woods on the north side of the railroad and had lain on top a small knoll a few feet away from the tracks. It had leaped at Dusiak as he came propelling along on a velocipede. The marks in the snow showed that a wolf had been attacking a man. Marks showed that the wolf had jumped at the man several times and had gradually worked the man to the forest, about 60 feet away from the right of way, which was composed of alders and small trees, mostly deciduous. The marks also showed, where a man in his desperation to keep away from the forest had gradually worked his way again to the railroad tracks and crossed over it in the course of the struggle to the area where the struggle was still taking place when Engineer Somers, Fireman Green and Brakeman Way-White stopped their train and got off the engine to give Dusiak a helping hand.

"Many human tracks were on the north side of the rails, showing that help had arrived and tracks were plentiful in the spot where the wolf was killed. Tracks leading to and from the railroad indicate that three men got off some sort of locomotive on the railroad and that three men again got on, presumably the locomotive standing on the C. P. R. tracks.

"I examined this wolf very closely before and after skinning and it was not nor had not been caught in either a trap or snare."

Signed: V. Crichton, Inspector
Chapleau, Ontario

Although wolves undoubtedly have attacked humans in the past, especially in Europe, the above accounts apparently make this particular instance one of the most authenticated cases in North America on record to date.—Randolph L. Peterson, *Division of Mammals, Royal Ontario Museum of Zoology, Toronto, Ontario.*

NEST BUILDING AND FOOD STORAGE OF A CAPTIVE CHIPMUNK

Howell (1929, North American Fauna No. 52, pp. 4–5) summarizes much data on food storage by chipmunks, both *Tamias* and *Eutamias*. Some of these records are really astonishing. Vernon Bailey, excavating a *Tamias striatus* burrow in Minnesota in July, found the nest "resting on a foundation of . . . 8 quarts of . . . acorns"; in another, which he dug out in New York in September, "about a peck of stored foods" was packed "around and under the nest". These were old nests in extensive burrows, and there is no way of knowing the time involved in the accumulation of the food caches, or whether each was the work of one or of several individuals. The present observations seem worth recording since they relate to a single individual for a known, and relatively short, period.

A female chipmunk (*Tamias s. striatus*), captured in November on the university campus in Chapel Hill, N. C., was confined in a cage in an unheated basement room, in which the windows were always open. She was offered acorns, sunflower seeds, dog biscuits, an occasional piece of apple or carrot, grapes, and sometimes bread crusts or meat scraps. The cage measured approximately 18 x 18 x 12 inches inside. On January 4 she was given a nesting box, its size approximately 8 x 5 x 4 inches, in which was placed a little straw and some shavings. A good deal of oat straw and excelsior was placed in the cage. This material gradually disappeared into the box, as did also a bunch of green carrot tops and, later, the greater part of a large piece of absorbent cotton, put in the cage when a period of very cold weather had been forecast. Beginning at this time her diet was limited chiefly to sunflower seed and apple, with some dog biscuit and bread. She was given the apple whole; when this was eaten away, usually in three or four days, she was given another. She gnawed for some days at the dry end of a rye bread loaf; when this disappeared she was given another and larger piece. Dog biscuits were put in the cage two or three at a time; it was apparent that they were being gnawed at, although slowly, and when they disappeared more were added. In a corner of the cage was a glass dish which held a small handful of sunflower seeds. About every other day, when only hull fragments would be left in the dish, it was cleaned and refilled with seed. On January 27 it seemed evident that the previous day's supply of seed had not been disturbed in the least. This was personally alarming, since she was a white-faced individual being kept for an heredity study, and since the first sign of fatal illness in three other chipmunks lost in December was failure to eat. As only a shred of apple remained she was given a fresh one, which within a few hours showed a good-sized hole, and our alarm abated somewhat. In the next ten days she took few, if any, seeds from the dish, but ate one apple and most of another. On February 7 she was trapped out of the cage for removal to an outdoor pen; she appeared to be perfectly healthy and normally lively. She had occupied the cage with nest box for 34 days, during the last 10 or 11 of which sunflower seeds did not disappear from her food dish, at least not in appreciable amount.

Her nest box was then opened, to reveal a truly surprising interior. It was so packed with nesting material and food one would not think that room enough was left for the chipmunk. At the top and upper sides was straw, excelsior and carrot tops. The middle was occupied by absorbent cotton which obviously had been pulled around and shaped, with a narrow burrow through its center. Beneath this was a foundation of food stores, mixed with which, and covering the floor of the box, was much chaff, consisting of sawdust (chewed up shavings), hull fragments of sunflower seed and bits of straw. 2000 sunflower seeds (about 1¼ pints when intact) were recovered; of these, 1310 (400 cc) were intact, while 590 (53 cc) had been hulled. There were 48 cc of hull fragments. The end of the rye bread loaf was there, only just small enough to have passed through the opening into the box, and numerous fragments of dog biscuit. The bread and dog biscuits amounted to 150 cc in volume, approximately. The total stored food, then, had a volume of 600 cc, or just over 20 percent of the total cubic capacity of the box (2850 cc). The added chaff, including the hull fragments, brings this food store foundation to 1050 cc or about 37 percent, leaving for the nest proper 1800 cc, that is, 63 percent of the total available space.

Only one small mass of feces was found in the nest box, about 1 cc in volume. Feces

were deposited almost invariably in one corner of the cage, the same corner being used the whole time.

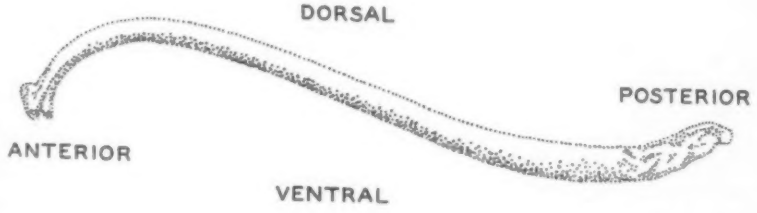
The evidence indicates that, in addition to a certain amount of other food (150 cc of bread and dog biscuit), this chipmunk stored at least 2000 sunflower seeds in about 22 days, or approximately 100 seeds per day (assuming that some of the stored seeds may have been eaten during the last 12 days). There is likewise indication that she ceased her storing activity only when the available storage space beneath the nest was filled up (or when a food foundation for the nest had been built up to a point that was in some manner "satisfactory" to her).

It is rather surprising that some of the seeds were hulled before storing, although most were stored intact. The presence of hull fragments indicate that many of the seeds were hulled within the box, but the volume of fragments is insufficient by far to account for all of the hulled seeds. Many of the latter were stuck together, in groups of two up to about six, which suggests that they were hulled outside, and carried into the nest box in the cheek pouches.

Although a few of the seeds were found scattered in the nest material itself, these were less than 5 percent of the total. Practically all of the food was in the bottom of the box, forming a foundation for the nest. Bailey noted a similar habit in the wild, as recorded by Howell. Like those humans who stuff their treasure of currency or coin in the mattress, the food-miserly chipmunk sleeps on his hoard.—WILLIAM L. ENGELS, *Department of Zoology, University of North Carolina, Chapel Hill, North Carolina.*

USE OF THE OS PHALLUS OF THE RACOON AS RIPPING TOOL

Recently while discussing Jellison's article of the origin of the os phallus (Jour. Mamm., vol. 26, no. 2 pp. 146–147, 1945.) with an old gentleman who had considerable knowledge of natural history, he told me that when he was a boy he had seen a number of local tailors use the os phallus of the racoon (*Procyon lotor*) as an instrument for taking out basting



threads and also as a ripping tool. The proximal end was always sharpened to a rather fine point. It would be interesting to know how wide-spread was the use of this bone among tailors of those days and if there are still those who so employ it. It appears that this is among the few instances of one of the small bones of mammals being put to practical use.—EDMUND C. JAEGER, *Riverside College, Riverside, California.*

FURTHER OBSERVATIONS ON SWIMMING AND DIVING OF MEADOW VOLES

While canoeing with my wife and Thomas McCormick, Jr., through Straight Shore Lake in Algonquin Provincial Park, Ontario, at 2:00 p. m. on September 4, 1946, an adult female meadow vole (*Microtus pennsylvanicus pennsylvanicus*) was observed swimming in the open waters of the lake. We immediately turned and overtook the animal. As we approached, the meadow vole attempted to dive and elude us but these dives consisted of mere shallow dips, scarcely going six inches under water. It seemed to have difficulty in staying under, swimming only two or three feet before coming to the surface. It swam

quite high in the water with most of its back exposed. As we passed along side with the canoe, Tom McCormick scooped the vole out of the water and threw it into the canoe. I recovered it and later made it into a specimen.

This animal had apparently started across the long narrow from east to west (about 75 yards) and was over 25 yards from the nearest shore.

While under water the animal could be seen quite clearly. It seemed to be quite fluffy and covered with air bubbles. Later examination of the animal indicated that it was not water soaked. Possibly longer exposure under water would have caused the animal to become at least partially water soaked and thus enabled it to swim greater distances under water as was reported by Blair (Jour. Mamm., vol. 20, no. 3, p. 375, 1939).—RANDOLPH L. PETERSON, *Division of Mammals, Royal Ontario Museum of Zoology, Toronto, Ontario.*

TEAT LOCATION IN THE CUBAN SOLENODON

When examining the external genitalia of a female almiquí, *Solenodon cubanus* Peters, the striking position of the mammary nipples was noticed and is reported here. The almiquí

PLATE 1

or ayre is a nearly extinct Cuban insectivore of the family Solenodontidae; another species of the same genus is found in Haiti.

The specimen studies had been captured near Baracoa and was being exhibited in the Havana Zoological Garden. Judging by the development of the nipples, it had been nursed. There were two symmetrically placed mammae whose teats were located in the hairless zone which surrounds the root of the tail. These teats were crural, as may be seen in Plate 1, not inguinal in position as they were reported to be by Allen (1910) and by Barbour (1945). The former classified the teats as "inguinal, or even post-inguinal." Each teat was located on the dorsum of the root of the corresponding thigh.

It is worthy to note that striking positions of the mammae have been reported in other insectivores by Deanesly (1934) and Brambel (1935).

As may be seen in Plate 1, an elliptical elevation like a rodet surrounded both orifices, anal and inguinal.

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JUAN J. ANGULO, *Department of Experimental Pathology, Havana University, Havana, Cuba.*

AN ACARIAN INFESTATION OF DERMESTID LARVAE

At the San Diego Natural History Museum, a large number of dermestid beetle larvae were found to be dying from an unknown cause. The beetle larvae, often extremely pestiferous, were being used in the preparation of skeletons to remove the flesh from the bones. In an effort to ascertain the cause of death, a study was made of random specimens of the beetle larvae. Examination revealed a rather heavy case of parasitism by what is commonly called the "straw itch mite" *Pediculoides ventricosus* (Newport). Males and both gravid and non-gravid females were found. When the mites were removed, small petechial lesions were noted on the body of the larvae. Since all the obviously ailing larvae examined were suffering from acariasis, the cause of death was attributed to this condition. The non-parasitized beetle larvae were all active and vigorous.

From a superficial examination, evidence of parasitism was lacking in most cases. However, after observing the "accordion-like" motion of the larvae, mites could be seen on the conjunctival membranes of the dorsum. In only a few cases were they observed attached to the tergum; the majority being located at the intertergal parts of the conjunctivae. As many as five or six males were present on some of the dorsal conjunctival zones. In the case of the larger gravid females, their numbers were much smaller.

Occasionally, mites could be observed wandering over small pieces of meat upon which the beetle larvae were feeding but it could not be ascertained whether or not the mites were also feeding on the meat. The beetle larvae were definitely the preferred choice of attachment for the mites. Ewing (A manual of external parasites, 1929) states that these mites have a remarkable symbiotic versatility. The same individual may be either a predator, a parasite or a scavenger during its own life period and apparently turns with the greatest facility from the one form of life to the other, depending upon the situation. They are frequently found associated with dipterous, hymenopterous, coleopterous and other insects upon which mites are often parasitic.

In many instances they have proven to be quite noxious to man. An irritating dermatitis, "straw itch," often results when man comes in contact with mite-infested straw in the fields, in straw-filled mattresses, or with contaminated straw in packing rooms and other places where this product is used.

Meticulous care in culturing dermestid colonies is necessary since there are no effective acaricides that would not damage the insect hosts. Prophylactic measures must therefore be employed to avoid infestation with mites since the therapeutic hazard is as great as the disease hazard.—WILLIS H. DOETSCHMAN, *9 Ronada Ave., Oakland 11, California.*

REVIEWS

Goodwin, George G. MAMMALS OF COSTA RICA. Bull. Amer. Mus. Nat. Hist., vol. 87, art. 5, pp. 271–474, figs. 1–50, pl. 17, map. 1.

This report based largely on the collection of Costa Rican mammals in the American Museum of National History, treats the 186 (my count indicated 188) forms of mammals known to occur in Costa Rica as well as 73 additional forms (more than half of which are bats) that are likely to occur there but as yet have not been definitely recorded.

The 188 forms are distributed as follows:

ORDER	NUMBER OF GENERA	NUMBER OF SPECIES	NUMBER OF SPECIES & SUBSPECIES
Marsupialia	5	6	8
Insectivora	1	4	4
Chiroptera	34	42	42
Primates	4	4	8
Edentata	7	7	8
Carnivora	14	21	24
Rodentia	23	46	83
Lagomorpha	1	3	3
Sirenia	1	1	1
Artiodactyla	3	4	5
Perissodactyla	2	2	2
Totals	95	130	188

"Owing to the geographic position of Costa Rica, widely ranging species of both the northern and southern halves of the Western Hemisphere broadly overlap. In general, however, the mammal fauna of the humid tropical eastern lowlands is separated from that of the arid Pacific coastal plains by species of the central mountain chain. Forms from Volcán Irazú and the Cordillera Central are typically Costa Rican, while those from the Talamanca Range [southeastern Costa Rica] show a tendency to intergrade with Panamanian species. The sharpest differentiation in the fauna occurs in the Guanacaste region and Volcania Range [northwestern Costa Rica] where the mammal fauna is definitely of a more nothern origin."

It is of interest that there is only one insectivore in Costa Rica, the short-tailed shrew *Cryptotis*; that the number of genera of bats far exceeds the number of genera of rodents; and that only 8 of the 130 species have a wide range north of Mexico—*Eptesicus fuscus*, *Lasiurus borealis*, *Sylvilagus floridanus*, *Procyon lotor*, *Mustela frenata*, *Urocyon cinereoargenteus*, and *Odocoileus virginianus*.

One new name, *Scotinomys teguina endersi*, is proposed. The South American and Central American opossums are considered conspecific, the author referring both to *D. marsupialis* which has priority. The peccary family is given as Tagassuidae and the genus as *Tagassu*, following the recommendation of Tate (Bull. Amer. Mus. Nat. Hist., vol. 76, p. 223, 1939). The specific name of the collared peccary is given as *T. tajacu*, a name proposed by Linnaeus which has precedence over *T. angulatus* Cope, 1889.

For each species there are given the original description, type locality, range, general characters, description, measurements, a list of specimens examined, and for most of them a brief account of their life history and habitat.

It would have been helpful had the author indicated by some conspicuous mark those forms that were admitted to the account but as yet are not recorded from Costa Rica. Also, a summary of taxonomic changes would have made the report more readily usable.

Those interested in the mammals of Central America in general and of Costa Rica in particular will find this publication a handy reference.—W. B. Davis.

Burt, William H. The Mammals of Michigan, University Michigan Press. Pp. xv + 288, 13 pls., 107 figs., 67 maps. 1946. Price $3.50.

The *Mammals of Michigan* is more than just another State list of mammals, for a good deal of material presented therein has application outside the boundaries of Michigan. The author approached his task with twofold purpose, (1) to provide a text or ready reference for natural history topics, or formal courses, in elementary schools, high schools or colleges, and (2) to provide a basis for further research on Michigan mammals. The degree to which he will achieve his aims, of course, remain to be determined, but this reviewer is anticipating much more than the usual reception accorded similar books.

Each of the 64 species of mammals known from Michigan within historic times is treated under the following heads: size, description, habitat, habits, distribution, and economic status. These accounts are simply and concisely written, and are understandable to anyone with an educational attainment of sixth grade level or above. For the more advanced laity and for students of natural history such technical information as diagnoses of Order and Family, dental formulae, etc., and reference to additional information on each genus are provided. Maps outlining in general fashion the range of the species in North America, and more specifically its range in Michigan by counties are very helpful and easily interpreted.

The book is well illustrated with numerous line drawings and thirteen color plates from the hand of Richard Philip Grossenheider. Miss Grace Eager provided drawings depicting key characters. All of these add materially to the usefulness of the book.

In addition to treatment of individual species, short chapters are provided on (1) faunal position of Michigan, (2) economic importance of mammals, (3) adaptive radiation, (4) home range and territories, (5) population, and (6) collecting and preparing specimens. Also, two artificial keys (one to skins only, the other to skulls only) to Michigan's mammals are provided. Judging the book for its value as a text, the sections 1–5 listed above are inadequately treated and, to this reviewer, constitute the chief weakness of the publication. An additional 100 pages of information on natural history and bionomics would not have increased unduly the size of the book yet they would have contributed materially to its value as a text.

In spite of any shortcomings it may have, this book should be made available to every school child in Michigan for it is in his hands that the future management of the state's natural resources lies, and knowledge is the basis for success.—W. B. Davis.

Leach, James W. Functional Anatomy of the Mammal. McGraw-Hill Book Company, Inc., New York. Pp. viii + 1–231, 96 text-figures. Octavo. Price $2.50.

This book is designed with a rather specific objective in view: to serve as an introduction to mammalian anatomy. Its greatest utility would seem to be as a precursor or substitute for courses in human anatomy. While it could, as the author suggests, serve as a guide in the "mammalian portion of courses in comparative vertebrate anatomy," it obviously has not been written to stress the comparative aspects of vertebrate anatomy, in spite of the fact that the cat-and-man comparisons are excellent.

Among the features which peculiarly fit it for the needs of students of human anatomy but at the same time mitigate against its utility in courses in comparative anatomy, are (1) the adoption of human rather than comparative descriptive terminology, such as *superior* instead of *anterior*, *anterior* instead of *ventral*, etc.; and (2) the more or less regional approach of the dissection, at least in some part. I believe teachers of comparative anatomy will regard the human terminology a distinct disadvantage, since it conflicts so completely with comparative ideas. It is, on the other hand, obviously of great value in the early training of students concerned only with human anatomy. The regional approach of the book is rather flexible at certain points, and often the material is more or less exten-

sively repeated in the systemic discussions. Some systems, like the skeletal, are treated almost wholly separate, while the discussion of various portions of the internal anatomy is, in a small part, regional. The point I wish to bring out is that the design does not well lend itself to a purely systemic study; in fact the book is avowedly *functional* in viewpoint. Such a viewpoint obviously treats functionally related features together irrespective of systemic relation. For the purpose the book was written, this is an admirable feature; in fact the strict adherence to the systemic procedure in dissection in many comparative anatomy courses is perhaps unwise.

There are many aspects of the book to be commended. It is expertly and thoroughly presented, with no more than minor deficiencies the number and nature of which of course vary according to the critic and his personal idiosyncrasies of emphasis. Obviously it is impossible for anything but the most complete treatise—clearly not desired for elementary classes—to include everything that each and every potential reader of the book may like; a compromise must be made, and I cannot criticize the one effected by Leach. What is given is well given; the entire ensemble is clearly the result of considerable experience, thought and ability.

One of the most pleasing features of the book is the rather considerable number of new drawings of cat anatomy. Many are far superior to any others generally available. A number of figures directly comparing details of cat and man are particularly useful. Unfortunately a few figures, as for example fig. 3.2, have not reproduced well, and others are somewhat hazy, diagrammatic or have a gray background that detracts from their sharpness. The other figures, selected from other works, are well chosen and appropriate. Clear comparison of cat and man is prominent throughout, in text as well as illustration. This is especially true of the chapter on muscles.

Another remarkable feature is the thoroughness with which function of all parts is considered. Muscle kinesiology is given much space—perhaps more than it deserves; the fundamentals of digestive, respiratory, excretory, reproductive and other phenomena are presented briefly and logically in the most appropriate places, where the structures involved are discussed. The book is replete with "sidelights" of special interest, such as the frequency and significance of occurrence of certain curious or popularly-known anomalies, variations or regular features in man which often have some connection with conditions occurring regularly or irregularly in the cat, and which at least can be interpreted and understood in the light of the study of the cat.

There is no doubt that the premedic, prenursing or predental student, or others with related interests, will gain much from a course in which this book could be used.

It consists of twelve chapters, several of which terminate with a series of problems the purpose of which is to provoke thought and application of the facts previously presented to new situations. They make the most of the theory that learning comes through use, and that the greater the variety of use the more thorough the learning and the more readily available the facts. It is good training for diagnosis.

The first chapter is devoted to General Considerations (22 pp., 8 figs.), which include well-selected topics: terms and definitions, the principle of homology, divisions of structural organization (types of tissues, organs, systems), anatomical position and posture, classification and characteristics of mammals and orders of mammals (with still further details on the classification and characteristics of cat and man), and anomalous and vestigial structures. The discussion of homology is particularly good; it is gratifying to the reviewer to observe another utilize the term "phylogenetic homology." Unfortunate, however, was the failure to make clear the necessity of the restriction in meaning of the terms "vestigial" and "rudimentary."

Chapter II treats the Skeletal System (36 pp., 25 figs.); III, Superficial Dissection (8 pp., 3 figs.); IV, Voluntary Muscles (44 pp., 14 figs.); V, Survey of Internal Anatomy (19 pp., 4 figs.); VI, Alimentary System (11 pp., 3 figs.); VII, Respiratory System (6 pp., 3 figs.); VIII, Vascular System (22 pp., 13 figs.), in which, commendably, the minor details

have been omitted; IX, Urogenital System (11 pp., 7 figs.); X, Nervous System (27 pp., 11 figs.); XI, Special Sensory Apparatus (8 pp., 4 figs.); and XII, Endocrine Organs (6 pp., 1 fig.). The book terminates with an appendix (4 pp.) on laboratory preparation and preservation of materials (including injection and preservation of dissection material, preparation of skeletal and fetal material, and bone and cartilage staining), and an index (7 pp.).

The mechanical expression of ideas, and the grammatical style, are not uniformly good. There is a tendency to delete the terminal *-al* on such words as *anatomical*, *physiological*, *histological*, *biological*, and *morphological*, but it is not consistent; I do not think it good at best. Homology "with" as well as "to" is spoken of at various points. The reviewer's preference is the former, although most authors use the latter; at any rate uniformity is to be desired. "As to," an awkward expression, is not infrequently used. Some statements are not properly modified, words are sometimes incorrectly used, and in a few cases the meaning of a statement is quite obscure.

An extraordinary number of important words are either not included in the index or are under some category where they are not readily found. The index should, I believe, have been made more nearly complete.

The value and even the legitimacy of the concept of "radial homology" as applied to the distal portion of the limbs in vertebrates is extremely dubious.

There is an unfortunate omission of the involuntary portion of the muscular system which, while not suitable for detailed study as is the voluntary portion of the system, is important enough to deserve some comment.

Use of the term "vascular" in place of "circulatory" appears unwarranted, in view of the fact that in many vertebrates a more or less extensive portion of the system is not vascular.

The range in size of mammals (p. 17) could well have been extended to 90 feet instead of 50 (the great blue whale is authoritatively recorded of this length), and thus the largest mammals would be about 1000 times (instead of 600) as long as the smallest, and a billion (instead of two hundred million) times as heavy.

While obviously not all anatomical details could be included, to the reviewer the oversight of many sesamoid bones; the cursory treatment of the ethmoid portion of the skull and of the hyoid apparatus; the omission of the comparative names of the wrist and ankle bones; omission of part and cursory treatment of the rest of the epaxial muscles; the omission of the tongue muscles and of an account of the details of relation between the rectus abdominis and the other hypaxial abdominal muscles or their aponeuroses; all detract from the usefulness of the book.

The cleithrum is implied erroneously (p. 42) to be a synonym of the clavicle.

The proof-reading has been very good. Few errors, as Dermaptera (an order of insects) instead of Dermoptera (an order of mammals); pre-and postzygophyses instead of -zygapophyses, cliethrum instead of cleithrum, etc., have crept in. In connection with the skeletal system a number of discrepancies occur between the spelling of names on the figures and in the text.—HOBART M. SMITH.

Thomas Hume Bissonnette and Earl Elmore Bailey. EXPERIMENTAL MODIFICATION AND CONTROL OF MOLTS AND CHANGES OF COATCOLOR IN WEASELS BY CONTROLLED LIGHTING. Annals of N. Y. Acad. Sci. 45, Article 6, pp. 221–260, 1944.

This is the third of a series of studies on pelt changes of mustelids through varying the duration of exposure to light. It well merits careful study by anyone interested in fur bearers because it disproves the common beliefs that temperature or color of the surroundings directly cause pelt changes.

The first two studies on ferrets, fitch and mink proved that decreasing exposure to light caused molting and the assumption of prime, winter pelts in summer. The weasel, with its color change at the time of molting, provided an animal on which pelage changes could be easily followed. A four-year study with long-tailed and Bonaparte's weasels showed

that at room temperature the animals could be made to change color or stay at a given point in the change by appropriate lighting. After a latent period of 3–3½ months, molting could be induced in either direction between brown and white or from white to white or brown to brown. Temperature is not entirely ruled out as a natural factor in pelt changes since lower temperatures may force certain species to spend more time in dark dens thus causing winter pelage to develop.—N. W. Hosley.

Anderson, Rudolph Martin. Catalogue of Canadian Recent Mammals. Canada Dept. Mines and Resources, Mines and Geology Branch, National Museum of Canada, Bull. No. 102, Biological Series No. 31, Ottawa, Canada, pp. v + 238, 1 fig. in text, January 24, 1947. Price $0.75.

The aim is to list each kind of mammal "known to exist, or to have existed within historic time, north of the southern boundaries of the Dominion of Canada, with exception of Alaska." For each of the 598 kinds there is given (1) the accepted scientific name, (2) vernacular name in English and in French, (3) synonymy which includes citation to the original description and to the first use of the name combination employed by Dr. Anderson in his Catalogue, (4) type locality, and (5) geographic range. The statements of range are supported not only by all published information known to Dr. Anderson but also by specimens, mostly in the National Museum of Canada, from previously unrecorded record stations. These detailed statements of geographic ranges make available now to all readers the wealth of information accumulated by Dr. Anderson on his Canadian explorations and in his many years of study and investigation of Canadian mammals.

Abundant footnotes direct the reader of the catalogue to revisions and other important literature. For many of the scientific names bestowed in honor of persons, footnotes provide data concerning those persons. The catalogue proper is followed by an account of the status of two introduced kinds of reindeer, a list of kinds of mammals likely to be found in the area with which the catalogue is concerned, "List of type localities", and an index to names, scientific and vernacular.

Pedomys, surprisingly, is accorded generic rank instead of merely subgeneric rank under the genus *Microtus*, some names of subspecies long in synonymy are resurrected, and some new name-combinations are used. *Blarina brevicauda manitobensis* (p. 23) is named as new from southern Manitoba, *Canis lupus knightii* (p. 54) is proposed for the subspecies of wolf in the forested areas of northern Manitoba and Saskatchewan, and *Microtus cantator* (p. 161) from the Yukon is described as a new species of the subgenus *Stenocranius*.

Dr. Anderson and the agency sponsoring his catalogue are to be congratulated on this important contribution to our knowledge of so large a part of North America.—E. Raymond Hall.

RECENT LITERATURE

(Conducted by Gerrit S. Miller, Jr., Remington Kellogg, and Emma M. Charters)

[Reprints of this section may be purchased from the Corresponding Secretary]

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COMMENT AND NEWS

FORMATION OF A COMMITTEE FOR THE STUDY OF ANIMAL SOCIETIES UNDER NATURAL CONDITIONS

At the conference on Genetics and Social Behavior held at the Roscoe B. Jackson Memorial Laboratory at the end of last summer, considerable emphasis was placed on the fact that although there is widespread interest in and enthusiasm for studies of the social behavior and organization of animals in many different scientific fields, these studies are often poorly supported and do not attract the attention they deserve. It was suggested that an informal "Committee for the Study of Animal Societies Under Natural Conditions" might serve a very useful purpose in encouraging and coordinating this type of scientific work.

The first meeting of this committee was held in New York under the auspices of the New York Zoological Society on January 31 and February 1, 1947. The primary purpose of the conference was to help organize a research program on animal behavior, particularly in connection with the New York Zoological Society's new station at Jackson Hole, Wyoming. A separate announcement of this project will be made elsewhere.

It was agreed that the committee should not identify itself with any one institution or project, and its organization was therefore set up on a broad basis. As a general directive for the committee's work the following resolution was passed:

"Realizing that the study of general problems of social organization is basically important to human welfare as well as to theoretical science, and realizing also that many animal societies are in danger of extinction and need to be studied while there is a chance that they may be saved, the undersigned have agreed to form a 'Committee for the Study of Animal Societies under Natural Conditions', whose purpose shall be to sponsor, coordinate, perform, and assist research on animal societies and to act as a liaison agency between workers in the various scientific fields involved in this research. It is agreed that the broadest possible interpretation shall be placed on the terms 'animal societies' and 'natural conditions'."

It was further agreed that the organization of the committee should remain flexible and informal, and it was decided to elect an executive secretary whose function shall be to coordinate the activities of the committee, and to elect chairmen of subcommittees to consider special research projects and conduct other activities.

At the New York meeting J. P. Scott was elected executive secretary and C. R. Carpenter chairman of a subcommittee on the Jackson Hole Research Project. T. C. Schneirla was elected chairman of a subcommittee to make a survey of locations and institutions in which research on animal social behavior and organization is possible, and also to locate projects which need to be encouraged. A further subcommittee on Ways and Means, with Fairfield Osborn as chairman, was organized for the purpose of finding out where financial support for this type of research can be obtained and is available.

Besides those mentioned above the following members of the committee were present at the meeting: Alfred Emerson, Nicholas Collias, Robert K. Enders, Myron Gordon, and William Beebe. Members who were unable to attend the New York meeting include: Frank A. Beach, S. Charles Kendeigh, Walter P. Taylor, John Emlen, and John W. Scott.

Action was initiated regarding the Barro Colorado Island Biological Station, which needs to be put on a permanent basis of support as a center of tropical research.

It is hoped that the secretary's office will act as a clearing house for research ideas and projects, and as a coordinating agency between various individuals and institutions interested in this line of research. The secretary was directed to take active steps in this direction, and correspondence on these matters is invited.—J. P. Scott, *Secretary for the Committee, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine.*

REPORT OF GOLDMAN MEMORIAL COMMITTEE

The Committee for the E. A. Goldman Memorial Number of the Journal of Mammalogy, published as the May 1947 issue, has turned over to the Treasurer of the American Society of Mammalogists all assets of the fund in total $980.70 received from 182 donors in 28 States and the District of Columbia. The Chairman expresses his appreciation for active assistance to the other members of the Committee, namely, C. M. Aldous, Rollin R. Baker, Seth B. Benson, W. J. Breckenridge, H. C. Bryant, William H. Burt, Paul Dalke, J. Kenneth Doutt, George G. Goodwin, William J. Hamilton, Stanley G. Jewett, E. R. Kalmbach, Barbara Lawrence, Joseph C. Moore, Viola S. Schantz, A. W. Schorger, Thomas G. Scott, Albert R. Shadle, Gustav A. Swanson, Walter P. Taylor, C. A. Tyron, Jr., and Frederick A. Ulmer, Jr.

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